Proposed
Total Maximum Daily Load for Nutrients
For the Lower St. Johns River

Dr. Wayne Magley and Daryll Joyner

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

1.1 Purpose of Report

This document presents Total Maximum Daily Loads (TMDLs) for Total Nitrogen (TN) and Total Phosphorus (TP) for the Lower St. Johns River (LSJR). The river was verified as impaired by nutrients based on elevated chlorophyll *a* levels in both the fresh and marine portions of the river, and will be included on the verified list of impaired waters for the LSJR Basin that is scheduled for adoption by Secretarial Order in August 2003. The TMDLs establish the allowable loadings of TN and TP to the fresh and marine portions of LSJR that would restore the river so that it meets its applicable water quality criteria for nutrients.

1.2 Development of the TMDL

This TMDL was developed in cooperation with the St. Johns River Water Management District (SJRWMD) as part of their development of Pollutant Load Reduction Goals (PLRGs) for the river. In recognition of the eutrophication-related impairment of the river, the Department of Environmental Protection (Department) and SJRWMD cooperatively developed a draft Plan of Study (POS) for the TMDL (Hendrickson and Magley, 2002) before the river was assessed for impairment under Chapter 62-303, Florida Administrative Code (Identification of Impaired Surface Waters, or IWR). As indicated in the POS, the SJRWMD (in conjunction with their contractor, the U.S. Army Corps of Engineers) was the lead agency for modeling activities, including development of a watershed model to estimate nonpoint source loads and development of a linked hydrologic/water quality model to determine the assimilative capacity of the river.

Both agencies also actively coordinated with a variety of local stakeholders throughout the TMDL development process, including meetings to discuss the POS and subsequent monthly meetings over the past year with a TMDL Stakeholders Committee and a TMDL Executive Committee. The TMDL Executive Committee is a broad-based stakeholder group that was convened by the Department of Environmental Protection's Northeast District in July 2002 (see Appendix A for membership). It has advised the Department on such issues as water quality targets and allocation processes. While the Department is clearly charged with implementing the TMDL Program, including the adoption of this TMDL by rule, this TMDL reflects consensus recommendations of the TMDL Executive Committee.

1.3 Identification of Water Body

The LSJR is that portion of the St. Johns River that flows between the mouth of the Ocklawaha River, its largest tributary, and the Atlantic Ocean, encompassing a 2,750-square mile (mi^2) drainage area (Figure 1). Within this reach, the St. Johns River is 101 miles long and has a water surface area of approximately 115 square miles. Major centers of population within the Lower St. Johns River Basin (LSJRB) include Palatka, a city of 10,700 at the southern entrance to the basin; Green Cove Springs, a city of 4,700 at the midpoint; and the Orange Park, Middleburg, and Jacksonville metropolitan area, with a population of over 1 million, in the northern portion of the basin (Floyd et al. 1997). The LSJR is a sixth-order, darkwater river estuary, and, along its length, it exhibits characteristics associated with riverine, lake, and estuarine aquatic environments (Phlips et al., 2000). Information about the river's hydrology

and geology are available in the Basin Status Report for the Lower St. Johns River Basin (DEP, 2002).

Figure 1. The Lower St. Johns River
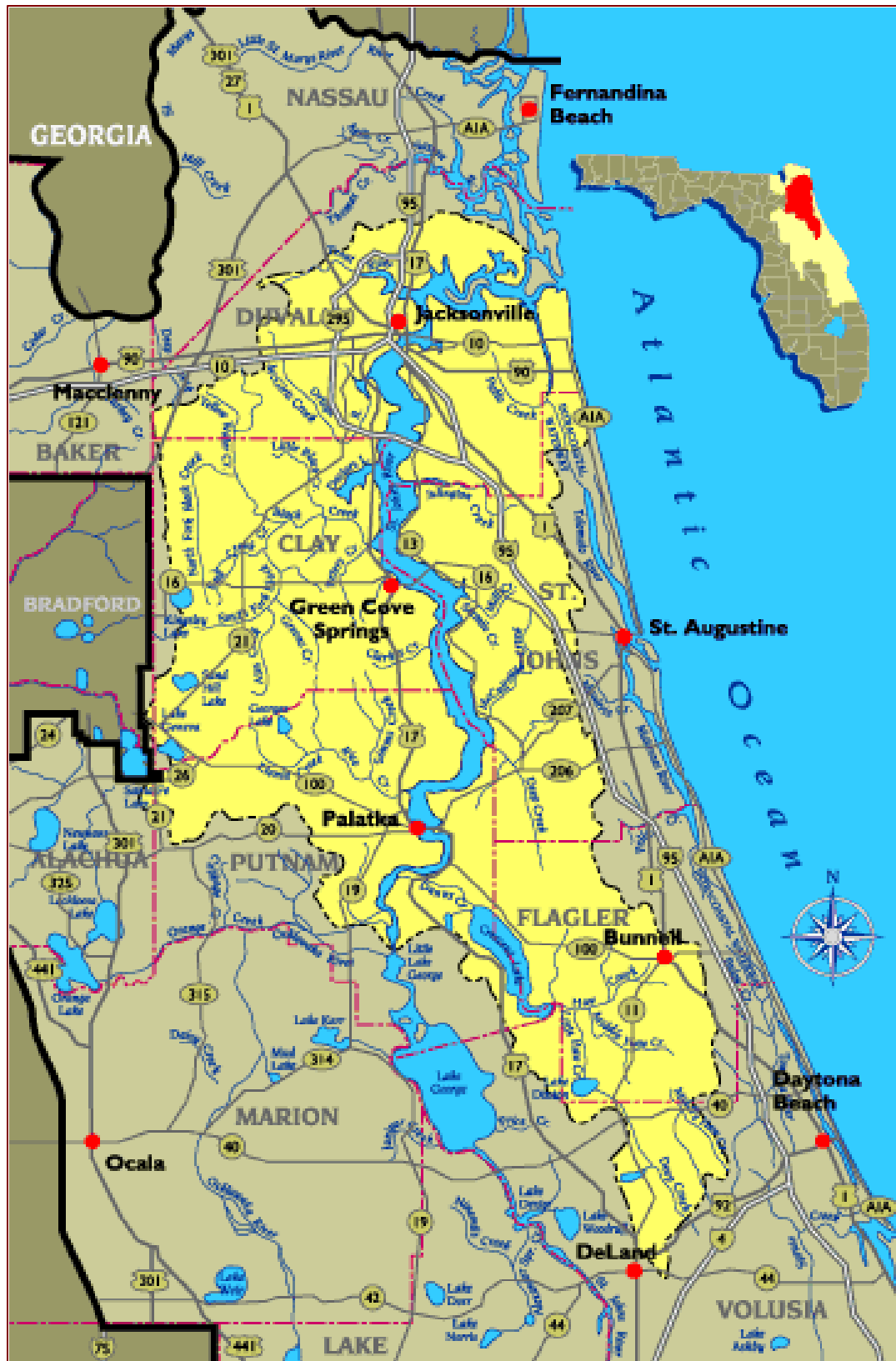
The LSJR can be divided into three ecological zones based on salinity (Figure 2). The three zones are 1) a predominantly fresh, tidal lake-like zone that extends from the City of Palatka north to the mouth of Black Creek; 2) an alternately fresh and marine, oligohaline lake-like zone extending from Black Creek northward to the Fuller Warren Bridge (I-95) in Jacksonville; and 3) a predominantly marine and much narrower zone downstream from I-95 to the mouth (Hendrickson and Konwinski,1998).

For assessment purposes, the Department has divided the Lower St. Johns River Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. The main stem of the LSJR has been divided into 15 segments, as shown in Figure 3.

2. STATEMENT OF WATER QUALITY PROBLEM

2.1 Verified Nutrient Impairment of the LSJR

Under the Section 303(d) of the Federal Clean Water Act, states are required to submit to the Environmental Protection Agency (EPA) lists of waters that are not fully meeting their applicable water quality standards (designated uses). The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. However, the 1999 Florida Watershed Restoration Act (FWRA, Chapter 403.067, Florida Statutes) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After a long rulemaking process, the Environmental Regulation Commission adopted the new methodology ias Chapter 62-303, Florida Administrative Code (Identification of Impaired Surface Waters or IWR) in April 2001.

The Department has subsequently used the IWR to assess water quality impairments in the main stem of the LSJR and verified that the majority of the fresh and estuarine segments of the river are impaired by nutrients (see Table 1). As noted in Table 1, 11 of the 15 LSJR segments were verified as impaired by nutrients based on annual mean chlorophyll *a* concentrations or annual mean Trophic State Index values. Annual mean chlorophyll a and TSI values for the verification period for each segment are available in the Department's files.

As required by the FWRA, the verified list of impaired waters for the LSJR was adopted by Secretarial Order (on September 4, 2003) before this TMDL can be adopted by rule (currently scheduled for adoption in September 30, 2003). Impairment associated with parameters other than nutrients will be addressed in separate TMDL development efforts in the timeframes indicated in the table.
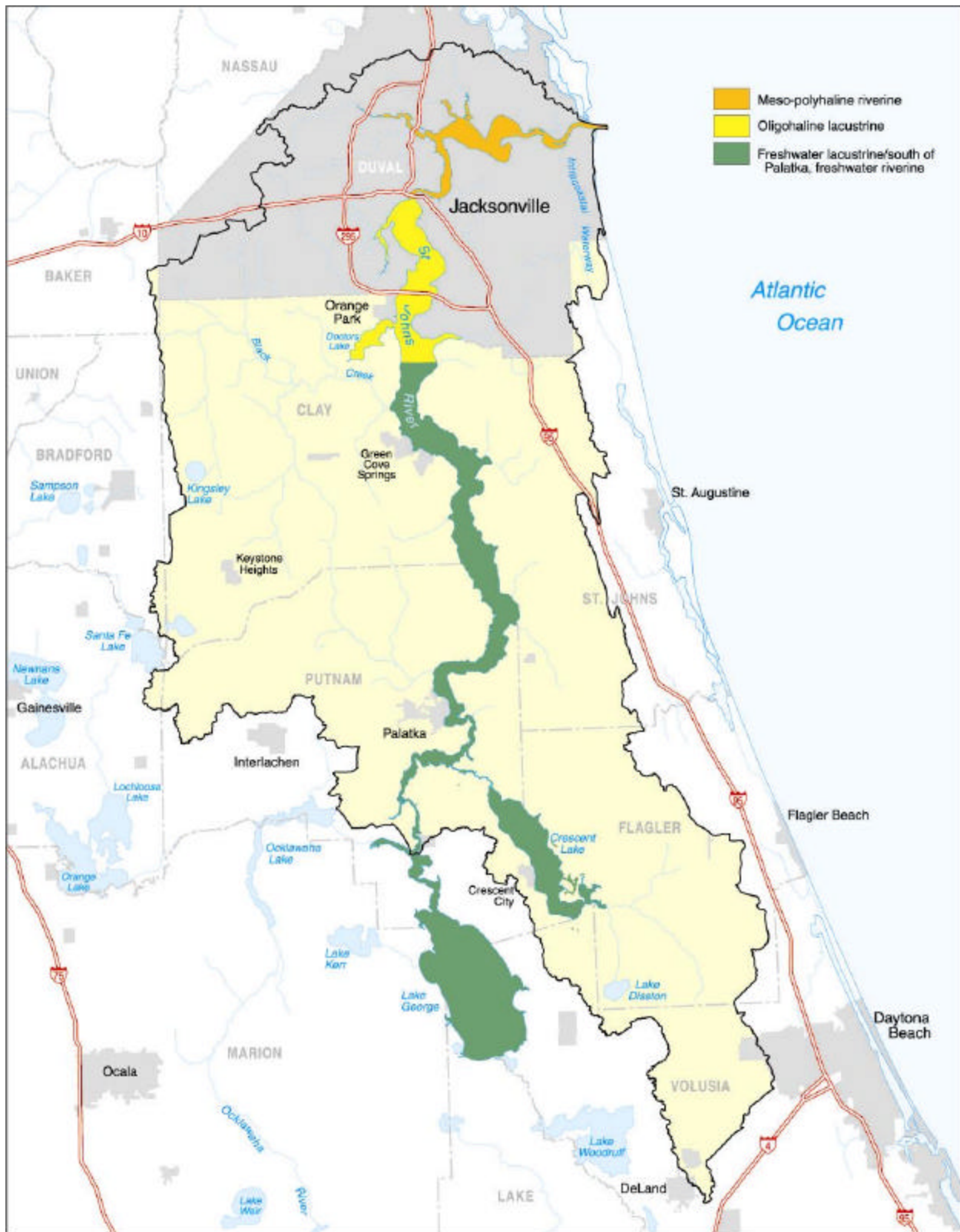
Figure 2. Ecological Zones of the LSJR
(Note: this figure inadvertently includes Lake George, which is not part of the Lower St. Johns River Basin.)

Figure 3. Waterbody Identification Numbers for the Main Stem of the LSJR

Table 1. Verified Impaired Segments of the Main Stem of the LSJR

WBID	Water Segment Name	Parameters of Concern	Priority for TMDL Development	Projected Year for TMDL Development
2213A	STJ RIV AB MOUTH	NUTRIENTS (HISTCHLA)	LOW	2008
2213A	STJ RIV AB MOUTH	IRON	MEDIUM	2008
2213B	STJ RIV AB ICWW	NUTRIENTS (HISTCHLA)	MEDIUM	2008
2213B	STJ RIV AB ICWW	LEAD	MEDIUM	2008
2213B	STJ RIV AB ICWW	COPPER	MEDIUM	2008
2213B	STJ RIV AB ICWW	IRON	MEDIUM	2008
2213B	STJ RIV AB ICWW	NICKEL	MEDIUM	2008
2213C	STJ RIV AB DAMES PT	NUTRIENTS (HISTCHLA)	(HIGH)	(2002)
2213C	STJ RIV AB DAMES PT	COPPER	MEDIUM	2008
2213C	STJ RIV AB DAMES PT	IRON	MEDIUM	2008
2213C	STJ RIV AB DAMES PT	NICKEL	MEDIUM	2008
2213D	STJ RIV AB TROUT RIV	COPPER	MEDIUM	2008
2213D	STJ RIV AB TROUT RIV	IRON	MEDIUM	2008
2213D	STJ RIV AB TROUT RIV	NICKEL	MEDIUM	2008
2213E	STJ RIV AB WARREN BRG	NUTRIENTS (CHLA)	(HIGH)	(2002)
2213E	STJ RIV AB WARREN BRG	COPPER	MEDIUM	2008
2213E	STJ RIV AB WARREN BRG	IRON	MEDIUM	2008
2213F	STJ RIV AB PINEY PT	NUTRIENTS (CHLA)	(HIGH)	(2002)
2213I	STJ RIV AB BLACK CK	NUTRIENTS (TSI)	MEDIUM	2008
2213J	STJ RIV AB PALMO CK	NUTRIENTS (TSI)	MEDIUM	2008
2213K	STJ RIV AB TOCIO	NUTRIENTS (TSI)	HIGH	2002
2213L	STJ RIV AB FEDERAL PT	NUTRIENTS (TSI)	HIGH	2002
2213M	STJ RIV AB RICE CK	NUTRIENTS (CHLA)	MEDIUM	2008
2213N	STJ RIV AB DUNNS CK	NUTRIENTS (CHLA)	MEDIUM	2008
2213G	STJ RIV AB DOCTOR LAKE	CADMIUM	MEDIUM	2008
2213I	STJ RIV AB BLACK CK	SILVER	MEDIUM	2008

Note: Table 1 also includes segments impaired by parameters other than nutrients (certain metals). These parameters are shown to provide a complete picture of the impairment in the river, but this TMDL only addresses the nutrient impairment.

2.2 Other Indications of Nutrient Impairment

In addition to the elevated chlorophyll *a* values (algal blooms) and low DO levels, a number of water quality problems have been identified that are widespread throughout the river that are indicative of an imbalance in the flora and fauna of the LSJR (DEP, 2002). These problems include a) fish kills; b) submersed aquatic shoreline vegetation covered in algal mats; c) excessive epiphyte growth further blocking light from submerged aquatic vegetation, d) anecdotal accounts of shoreline vegetation losses and reduced recreational fishing quality; e) river sediment conditions indicative of low benthic animal diversity; f) excessive organic matter sedimentation and prolonged anoxia; and g) the presence of potentially toxic dinoflagellates such as the *Pfiesteria*-like *Crytoperidiniopsoids* (Burkholder and Glasgow 1997a, 1997b), and

Prorocentrum minimum (Phlips and Cihcra, 2000), often co-occurring with fish kills or ulcerative disease syndrome in fish. All of these problems are connected by a common thread – they indicate a condition of accelerated eutrophication in an estuarine environment (see Appendix B for a discussion on eutrophication).

Numerous other studies have identified either high nutrient concentrations (NOAA, 1989) or eutrophic conditions (Bricker et al. 1999; EPA, 2001; Janicki, 2000) in the lower St. Johns River. In their assessment of nutrient loads to the LSJR and their potential effects, Hendrickson and Konwinski (1998) determined that

> 1) a combination of point and nonpoint source pollution has increased the within-basin nutrient load to the LSJR 2.4 times over natural background for TN and 6 times for TP;

> 2) areal nutrient loading, at 9.7 and 2.1 kilograms of nitrogen and phosphorus per hectare of watershed contributing area per year within the LSJR Basin is one of the highest reported from studies in the southeastern United States;

> 3) point sources were the greatest contributor of anthropogenic nutrient load from within the basin. However, due to the entry of this load nearer to the mouth of the river, its incremental effect is presumed to be less than that caused by nonpoint sources and upper and middle St. Johns River loads which enter upstream; and

> 4) changes in the amounts of river algae appear to correlate significantly with changes in inorganic nitrogen and DO, suggesting that algae use much of the nitrogen supplied to them for growth.   During this cycle of growth and ultimate death the algae exert a dominant influence over river oxygen content.

Based upon these findings, it is clear that the lower St. Johns River 1) receives high nutrient loads and is nutrient enriched, and 2) exhibits the symptoms of estuarine eutrophication. While nutrient enrichment is not the only problem leading to impaired water quality in the lower St. Johns River, it is probably the most wide-spread and multi-faceted.

3.0 DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND WATER QUALITY TARGETS

3.1 Classification of the LSJR and Criteria Applicable to TMDL

The LSJR is a Class III water body, with a designated use of recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criteria applicable to the impairment addressed by this TMDL are the dissolved oxygen (DO) criterion and the narrative nutrient criterion.   It should be noted that none of the LSJR WBIDs were verified for DO impairment using the IWR methodology, which uses a 10% exceedance frequency to verify impairment. However, continuous DO monitoring data collected in both the freshwater and marine reaches of the river (at the Dames Point Bridge station and to a lesser extent the Acosta Bridge station) from 1996 through 2001 indicated periods when DO concentrations were below the criterion in each of these portions of the river. As these values were at levels that could adversely impact aquatic fauna, the nutrient TMDL also needed to address the impact of nutrients on DO levels.

3.2 Dissolved Oxygen Criterion

The applicable Class III DO criterion varies depending on whether a water body is "predominantly marine[1]" or "predominantly fresh." The freshwater criterion applies in the predominantly fresh, tidal lake-like zone that extends from the city of Palatka north to the mouth of Julington Creek, and in the alternately fresh and marine, oligohaline lake-like zone extending from Julington Creek northward to the Fuller Warren Bridge (I-95) in Jacksonville. The marine criterion applies in the predominantly marine zone downstream from the Fuller Warren Bridge to the mouth.

The Class III DO criterion for predominantly fresh waters is a minimum DO of 5 mg/L, and the criterion for predominantly marine zones is a minimum DO of 4 mg/L, with a minimum daily average of 5 mg/L. However, DO levels are known to naturally fluctuate below the DO criterion for both predominantly fresh and marine waters in the LSJR, and Florida Water Quality Standards (Chapter 62-302, F.A.C.) state that natural conditions should not be abated. In Section 403.021(11) [2], Florida Statutes (F.S.), the Florida Legislature recognized that water quality can naturally vary below the applicable criteria and directed that water quality standards should be reasonably established and applied to take natural variability into account.

To address this natural variation below the criterion, the SJRWMD (Hendrickson 2003, draft document in preparation, relevant portions of the text provided as Appendix C) evaluated a more appropriate DO target for the estuarine portions of the river using a methodology similar to that included in the EPA assessment of dissolved oxygen criteria for Cape Cod to Cape Hatteras. In this document, Ambient Water Quality Criteria for Dissolved Oxygen (salt water): Cape Cod to Cape Hatteras (EPA, 2001), EPA proposed refined criteria for Virginian province estuaries that specify a minimum DO of 2.3 mg/L for a 24-hour exposure thus assuring juvenile and adult fish survival, and a minimum of 4.8 mg/L for a 24-hour exposure for protection against adverse growth effects of fish.

Although the EPA guidance was developed for Virginian Province estuaries, a number of species on which the guidance was developed are also known to be present in the LSJR Estuary, based on non-game fisheries monitoring data (FMRI, 2002). In the absence of a specific guidance for south-Atlantic estuaries, the Virginian-province guidance provided the most objective, resource-based assessment available.

This guidance was useful because it provided a better target to evaluate episodic, low DO events. This methodology provides for a more appropriate DO target than the criterion because it addresses both absolute minimum DO values for the protection against acute effects and sub-lethal DO values for the protection against reductions in growth and recruitment. These values

---

[1] Surface waters in which the surface chloride concentration at the surface is greater than or equal to 1,500 milligrams per liter (mg/L) are considered "predominantly marine" (F.A.C. 62-302).

[2] (11) It is the intent of the Legislature that water quality standards be reasonably established and applied to take into account the variability occurring in nature. The department shall recognize the statistical variability inherent in sampling and testing procedures that are used to express water quality standards. The department shall also recognize that some deviations from water quality standards occur as the result of natural background conditions. The department shall not consider deviations from water quality standards to be violations when the discharger can demonstrate that the deviations would occur in the absence of any human-induced discharges or alterations to the water body.

are combined into one relationship, termed the "persistent exposure criteria," that can be used to evaluate the intensity and duration of a given low DO event.

It should be noted that the nutrient TMDL for the estuarine portion of the St. Johns River is based on maintaining DO levels above those that have been calculated using this EPA method rather than the applicable state DO criterion. In acknowledgement of this distinction, the SJRWMD and Department are pursuing development of a SSAC for DO for this portion of the river in accordance with Rule 62-302.500(2)(f) F.A.C. Since the segments in this portion of the river meet water quality standards for DO based on the IWR and this TMDL proposes nutrient reductions to address a nutrient impairment, it will only have beneficial impacts on DO. Therefore, even though FDEP is not using the approved water quality standard as a target for this TMDL, implementation will not result in degradation with respect to DO. In addition, the SJRWMD will continue work related to nutrient loads and algal response for this section of the river. Algal response to increased nutrient loads would be more appropriate to use when evaluating the narrative nutrient criterion, which has balanced, natural populations of aquatic flora and fauna as its endpoint.

3.3 Nutrient Criterion

Florida's nutrient criterion is narrative only - nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. Accordingly, a nutrient related target was needed to represent levels at which an imbalance in flora or fauna is expected to occur. While the IWR provides a threshold for nutrient impairment for streams and estuaries based on annual average chlorophyll *a* levels, these thresholds are not standards and need not be used as the nutrient-related water quality target for TMDLs. In fact, in recognition that the IWR thresholds were developed using statewide average conditions, the IWR (Rule 62-303.450) specifically allows the use of alternative, site-specific thresholds that more accurately reflect conditions beyond which an imbalance in flora or fauna occurs in the water body.

As part of the PLRG development, the SJRWMD established a site-specific threshold for nutrient impairment for the freshwater zone based on chlorophyll *a* values (Hendrickson et al., 2003, draft report in preparation). Hendrickson evaluated the maximum algal biomass levels that would a) maintain diversity of the plankton community, b) facilitate upward transfer of primary production to higher trophic levels (and maintain zooplankton diversity), and c) minimize the potential of dominance of detrimental algal species and production of algal toxins. He found that a chlorophyll *a* target of 40 ug/L (micrograms per liter) not to be exceeded more than ten percent of the timewould protect the aquatic flora and fauna of the river.

Studies have shown that when chlorophyll *a* levels rise above 40 ug/l, a shift in algal types occurs: blue-green algae begin to dominate the system, toxic algal species begin to increase, and zooplankton communities begin to decline. While maintaining chlorophyll *a* levels below 40 ug/l 90 percent of the time may prevent an imbalance in natural populations of aquatic flora and fauna under average conditions, it is uncertain whether these levels will be fully protective in this portion of the river under critical flow conditions, in a prolonged low flow situation, or during the extended growing season with less than average flows. For this reason, continued study of the river system is necessary to determine if a seasonal average maximum or yearly average maximum level of chlorophyll *a* should be established to protect against imbalances in natural populations of aquatic flora and fauna due to high nutrient levels.

Specifically, a series of studies is needed to demonstrate: (1) that progress is being made towards reducing nutrient loads by the required 30% or that progress towards reaching the percent reduction goal is being made, (2) that once the 30% reduction goal is reached, it has resulted in chlorophyll a levels that do not exceed 40 ug/l more than 10% of the time, and (3) that once the chlorophyll a target is reached, it has resulted in achievement of the narrative nutrient criterion (i.e., balanced, natural populations of aquatic flora and fauna).

It should be noted that the ten percent exceedance frequency is based on Hendrickson's conclusion that chlorophyll a values should not exceed 40 ug/L for more than 40 consecutive days (10% of a year = 36.5 days). However, as discussed in the modeling section, the water quality target is being implemented as a long-term average value rather than a worst case year, in recognition of the high annual variability in river flow.

4. DETERMINATION OF CURRENT LOADING

4.1 Types of Sources

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of nutrients in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either "point sources" or "nonpoint sources." Historically, the term point sources has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term "nonpoint sources" was used to describe intermittent, rainfall driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, runoff from agriculture, runoff from silviculture, runoff from mining, discharges from failing septic systems, and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under EPA's National Pollutant Discharge Elimination Program (NPDES). These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and from a wide variety of industries (see Appendix F for background information about the State and Federal Stormwater Programs).

To be consistent with Clean Water Act definitions, the term "point source" will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) AND stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see Section 6). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Background

This section describes the approach used to determine external nutrient loads to the LSJR. The external load assessment was intended to determine (1) the spatial and temporal characteristics of the external load to the LSJR and, ultimately, and (2) the effectiveness and costs associated with strategies for reducing this load. Assessing the external load entailed monitoring and research projects to determine the volume, concentration, timing, location, and underlying

nature of point, nonpoint, and atmospheric source additions to the river stem and tributary mouths below the head of tide. The subsections below describe the approaches used for assessing each of these major external load categories. Figure 4 identifies tributary water quality sampling stations, stream gauging stations, and major point sources in the basin.

Because the computations involved in the development of the external load for the LSJRare so instrumental in the outcome of TMDLs and PLRGs, they were reported in a separate document (Hendrickson et al, 2002).

Figure 4. Data collection and monitoring stations of the external load assessment element of TMDL development for the lower St. Johns River

Source: /soros/mcvallers/arcview/projects/hendrickson_maps.apr 11/29/2000
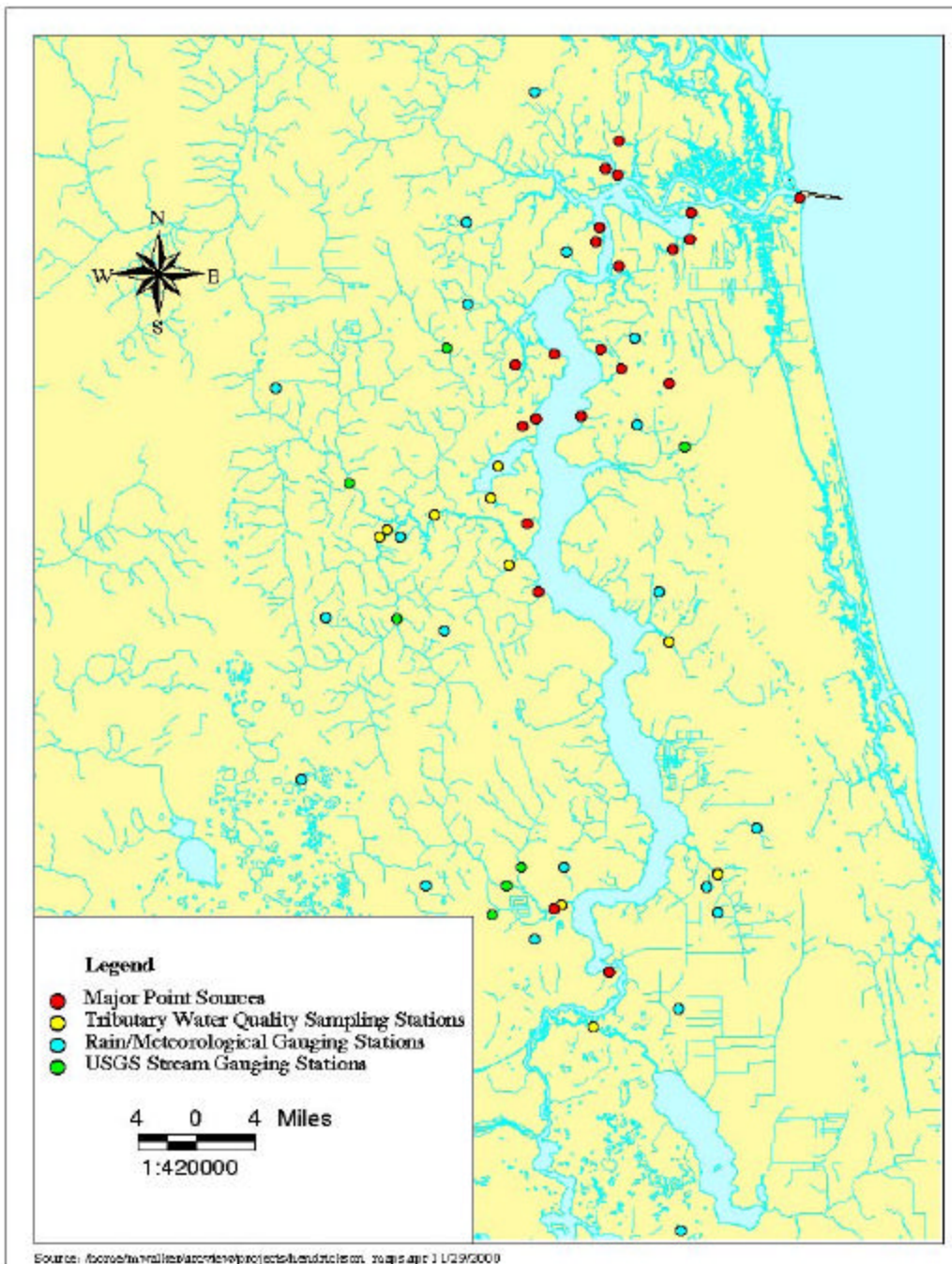
Permitted Point Sources

<u>Inventory of Point Sources</u>

There are 36 permitted wastewater treatment facilities that discharge nutrient loads directly into the LSJR (Table 2), with a total of 32 domestic wastewater facilities and 4 industrial wastewater facilities. These facilities, which are permitted through the National Pollutant Discharge Elimination System (NPDES) Program. are estimated to contribute approximately

Table 2. Permitted Wastewater Facilities Discharging to the LSJR

Name of Facility	Facility ID	Permitted Flow (MGD)	1997-98 Nutrients	
			TN (mg/L)	TP (mg/L)
SMURFIT-STONE CONTAINER CORPORATION	FL0000400	20	6.8	1.1
JEFFERSON SMURFIT – JAX	FL0000892	6	8.8	1.2
USN - NS MAYPORT WWTF	FL0000922	2	3.2	2.1
USN - NAS JACKSONVILLE WWTF	FL0000957	3	8.5	1.7
GEORGIA-PACIFIC	FL0002763	40	5.5	1.4
JACKSONVILLE BEACH WWTF	FL0020231	4.5	9.1	2.2
NEPTUNE BEACH WWTF	FL0020427	1.5	8.8	1.4
GREEN COVE SPRINGS – Harbor Road WWTF	FL0020915	0.75	9.2	2.9
WESMINSTER WOODS - (Wesley Manor Retirement Village)	FL0022489	0.09	4.6	2.0
ATLANTIC BEACH – BUCCANEER WWTF	FL0023248	1.9	13.4	1.4
JEA - MANDARIN WWTF	FL0023493	7.5	5.34	2.3
JEA - MONTEREY WWTF (operated by UWF)	FL0023604	3.6	11.3	2.6
JEA - HOLLY OAKS WWTF (formerly UWF)	FL0023621	1	8.3	2.1
JEA - SAN JOSE WWTF (formerly UWF)	FL0023663	2.25	10.0	2.9
JEA - JACKSONVILLE HEIGHTS WWTF (formerly UWF)	FL0023671	2.5	10.1	2.9
ORANGE PARK WWTF	FL0023922	2.5	-	3.7
JEA - SAN PABLO WWTF (formerly UWF)	FL0024767	0.75	6.5	3.5
CCUA - MILLER STREET WWTF	FL0025151	4.99	4.5	3.2
JEA - ORTEGA HILLS WWTF (formerly UWF)	FL0025828	0.22	16.8	2.3
JEA - BUCKMAN WWTF	FL0026000	52.5	10.5	4.7
JEA - ARLINGTON WWTF	FL0026441	20	14.3	2.6
JEA - NORTHEAST WWTF (aka JEA – DISTRICT II WWTF)	FL0026450	10	22.7	5.9

JEA - SOUTHWEST WWTF	FL0026468	10	10.5	1.4
JEA - ROYAL LAKES WWTF (formerly UWF)	FL0026751	3.25	7.8	3.8
FWSC - BEACON HILLS SD WWTF	FL0026778	1.3	11.9	2.0
FWSC - WOODMERE SD WWTF	FL0026786	0.7	11.6	1.7
GREEN COVE SPRINGS – SOUTH WWTF	FL0030210	0.5	13.6	2.3
CCUA - FLEMING OAKS WWTF	FL0032875	0.49	3.0	1.9
ATLANTIC BEACH – MAIN WWTF (D001)	FL0038776	3	11.4	2.1
PALATKA WWTF	FL0040061	3	14.7	2.4
ANHEUSER BUSCH – MAIN ST – LAND APP	FL0041530	2.6	3.9	0.3
HASTINGS WWTF	FL0042315	0.12	4.5	0.6
JEA - JULINGTEEN CREEK WWTP	FL0043591	0.476	12.0	3.0
CCUA - FLEMING ISLAND WWTF (combined)	FL0043834	6.365	-	-
UWF - SAINT JOHNS NORTH WWTF	FL0117668	n/a	6.5	1.7
BRIERWOOD SD – BEAUCLERC STP	FL0023370	n/a	-	-

27% and 55% of the annual average above-background TN and TP loads, respectively, to the LSJR.

Domestic wastewater facilities that discharge to surface waters are concentrated along the St. Johns River from Green Cove Springs to its mouth north of Jacksonville, and further south near Palatka. The largest domestic wastewater dischargers in the basin are the wastewater treatment facilities associated with the City of Jacksonville in the northern (downstream) end of the basin, including the Buckman Street, Arlington East, JEA District II, Southwest District, and Mandarin wastewater treatment facilities. Several of these facilities participate in reuse programs, and most are seeking ways to either include or improve nutrient removal treatment (FDEP, 1997; Hendrickson and Konwinski, 1998).

All domestic wastewater facilities discharging to the St. Johns River are required, at a minimum, to monitor for conventional pollutants such as Total Suspended Solids (TSS), carbonaceous biological oxygen demand (CBOD 5), and fecal coliforms bacteria (FDEP, 1997). While most permits do not include nutrient effluent limits, nutrients must be monitored in many systems because of their potential negative effects on surface water, including their role in the formation of nuisance and harmful algal blooms.

Large industrial dischargers in the basin include power plants, pulp and paper mills, chemical plants, and manufacturing plants. The majority of industrial plants send their process wastewater through pretreatment facilities to Publicly Owned Treatment Works (POTWs) such as the Buckman plant. Facilities with significant nutrient discharges to the main stem of the LSJR include the Georgia-Pacific Corporation (which produces bleached and unbleached pulp and paper), Stone Container (which changed from a pulp and paper mill to a recycling mill in the 1990s, reducing the volume of discharge), and Anheuser-Busch (a brewery). Remaining discharges include non-process wastewater such as cooling water, softener regenerate and boiler blowdowns which do not contribute a significant nutrient load.

Estimating Point Source Loads

Point source effluent loads were calculated through a combination of monitoring data and statistical extrapolation to fill monitoring gaps. Point source loads were estimated for only those facilities that discharge directly to the LSJR or to tributary mouths below the head of tide.

Monthly operating report data from treatment facilities were used to create a time-varying input data set for effluent flow and nutrient, suspended solids, and biological oxygen demand concentrations. Weekly, monthly, or quarterly monitoring data for water quality concentrations were multiplied by daily flow data to determine daily load. For facilities that lack complete chemistry data, mean values from the facility or from similar facilities were used to complete the missing record.

Water quality monitoring data collected for facilities during a 1993–95 point source assessment project were also available and were combined into a GIS database that also includes outfall locations and sewer service coverage area. Outfall locations were then used to identify the appropriate model grids where these sources entered the system

Municipal Separate Storm Sewer System Permittees

Like other nonpoint sources of pollution, urban stormwater discharges are associated with land use and human activities, and are driven by rainfall and runoff processes leading to the intermittent discharge of pollutants in response to rain storms. The 1987 amendments to the Federal Clean Water Act designated certain stormwater discharges from urbanized areas as point sources requiring NPDES stormwater permits. The three major components of the NPDES stormwater regulations are:

? Municipal Separate Storm Sewer Systems (or MS4) permits that are issued to entities that own and operate master stormwater systems, primarily local governments. Permittees are required to implement comprehensive stormwater management programs designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable.
? Stormwater Associated with Industrial Activities, which is regulated primarily by a multisector general permit that covers various types of industrial manufacturing facilities and requires the implementation of stormwater pollution prevention plans.
? Construction activity generic permits for projects that disturb one or more acres of land and which require the implementation of stormwater pollution prevention plans to provide for erosion and sediment control during construction and the treatment and management of stormwater to minimize pollution and flooding.

Within the Lower St. Johns River Basin, the stormwater systems owned and operated by local governments and the Florida Department of Transportation within the urbanized areas of Duval

County are covered by an NPDES MS4 permit. Additionally, several other local governments within the basin have applied for coverage under the Phase 2 NPDES MS4 permit. Within Clay, Duval, Flagler, and St. Johns counties, 223 industrial facilities have received coverage under the multisector generic permit or the no exposure exemption.

4.4 Nonpoint Sources

Nonpoint sources of nutrient loading to the LSJR include septic tanks, marinas, silviculture, row crop agriculture, dairies, stormwater from urban development and tributaries (including Black Creek, Dunns Creek, Deep Creek, Rice Creek, Julington Creek, Trout Creek, Sixmile Creek, Governors Creek, Clarkes Creek, Cedar Creek, Camp Branch, Mill Branch, and Dog Branch). Unlike traditional point source effluent loads, nonpoint source loads enter at so many locations and exhibit such large temporal variation that a direct monitoring approach is infeasible except for the largest, most significant inputs. Those largest inputs are the upstream boundary of the lower St. Johns River at Buffalo Bluff, Dunns Creek, and the downstream boundary at the Atlantic Ocean. For all other nonpoint entry points, watershed modeling was used to complete the external load budget.

4.4.1 Pollution Load Screening Model

The watershed model used to estimate nonpoint source loads was the Pollution Load Screening Model (PLSM; Adamus and Bergman 1995; Hendrickson and Konwinski 1998). The PLSM uses a computer-driven geographic information system framework to develop aggregate whole basin loads of relevant water quality constituents. The computational approach of the PLSM calculates constituent load as the product of concentration and runoff water volume, using nonpoint source pollutant export concentrations specific to one of 15 different land use classes, and water quantity through a hybrid of the Soil Conservation Service (SCS) curve number method.

In the LSJR application, four significant modifications were made to the model framework:

   1) the model time step was shortened to seasonal, rather than annual average loading rates, to account for seasonal differences in specific land use export concentrations and runoff quantity;
   2) eight additional water quality variables have been added: orthophosphate, total inorganic nitrogen, labile (easily broken down) organic carbon, nitrogen and phosphorus and refractory (slowly broken down) organic carbon, nitrogen and phosphorus;
   3) land-use loading rates have been adjusted to monitoring data collected within the LSJR basin using a linear multiple regression best-fit approach based on contributing land-use fractions in calibration watersheds; and
   4) hydrologic predictions have been improved by using an adjusted water quantity based on the deviations in long term rainfall patterns.

4.4.2 Atmospheric Deposition

A review by Paerl (1993) has shown that atmospheric deposition contributes 10% to 50% to the nitrogen budget of estuaries world-wide. In Chesapeake Bay, it has been estimated that 25% of the human-caused nitrogen load originates as atmospheric deposition (Fisher and Oppenheimer, 1991). In Tampa Bay, atmospheric deposition has been determined to provide

29% of the total nitrogen load, (Pribble and Janicki, 1998), making it the second leading source of nitrogen to the bay (Greening et al., 1997).

In their original calculation of nutrient budgets for the LSJR, Hendrickson and Konwinski (1998) estimated that atmospheric wet deposition contributed 15% of the total inorganic nitrogen to the river on an annual average basis and 21% during the peak algal bloom season from April through July. However, a reporting units error was subsequently discovered and the estimated contribution from atmospheric deposition was reduced to about 4% per year. Due to the coarseness of this original estimate, a more detailed atmospheric deposition load assessment was deemed necessary. A recently completed assessment of atmospheric deposition load to the LSJR (Pollman and Roy, 2003) determined that approximately 2% of the total nitrogen load, and 10% of the inorganic nitrogen load, is supplied through direct atmospheric deposition. The objective of this assessment was to increase the precision of the atmospheric load estimate, and to determine if spatially and temporally varying input is needed to adequately describe nutrient enrichment. The assessment also included a greater number of nutrient forms, dry and wet deposition, an increased number of stations, and an examination of existing data.

Atmospheric deposition of phosphorus was not included in the modeling and TMDL assessment because it is expected to be a very minor source of phosphorus to the basin.

4.4.3 Sediment Flux

The bottom sediment-water interface represents an important boundary for the exchange of nutrients, carbon, and oxygen. As such, the upward and downward flux of these constituents must be assessed to properly account for characteristics of water column water quality. This is particularly true of broad, shallow, slow-moving rivers such as the LSJR, where positive (i.e., upward) flux from the sediment undoubtedly makes up a significant portion of the bioavailable nutrient load during certain times of the year. While river sediments represent a transient source of relevant constituents, sediments differ from other sources in that they are not a net positive source (e.g., not a true *external* source), and hence are not listed as a general allocation category in the following section. Over the long term, accrual of material to the sediment is positive, and long-term net upward sediment flux is negative. In general, long term net accrual to the sediments is proportional to the sources to a particular river reach, thus the effect exerted by transient upward nutrient flux can likewise be considered to be proportional to the external sources.

Several studies have been performed to quantify the composition and accretion rate of LSJR sediments. Presentations at the October 14-15, 2002 St. Johns River Symposium by Malecki and White, Jaeger and Mausner; Chavan and Ogram; and DePinto, Kaur and Bierman Jr summarized findings from these studies. The studies were designed specifically to provide input data necessary for dynamic sediment flux modeling for the LSJR TMDL and PLRG determination.

4.5 Loading Inventory

Estimated nonpoint source loads for the LSJR are shown in Appendix D (Tables D1 – D5), and summarized TN and TP loads for 1995 through 1999 are shown in Figures 5 and 6, respectively. As noted in the pie charts, upstream sources are the dominant TN load to the LSJR, while LSJR nonpoint and point source TP loads are roughly equivalent to the upstream TP load.

Figure 5 TN Loading to the LSJR by Source Category

Lower St. Johns River Nitrogen Load Summary
1995-99

Upstream (Middle St. Johns, Ocklawaha and Crescent Lake
LSJR Basin Nonpoint Source
LSJR Basin Point Source

Dotted - Anthropogenic
Clear - Natural Background
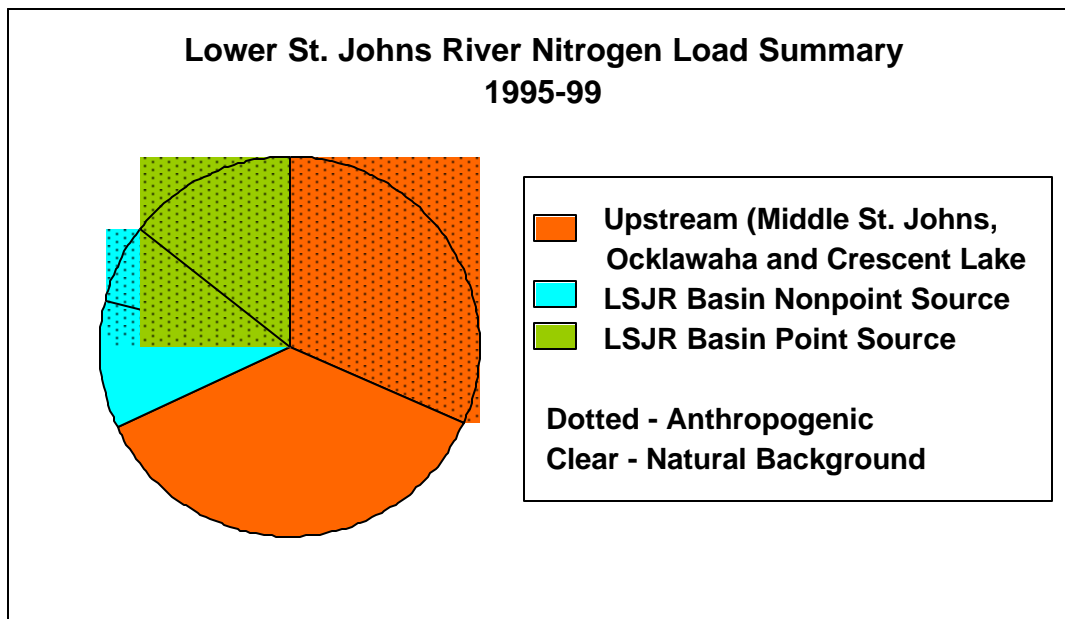
Figure 6 TP Loading to the LSJR by Source Category

Lower St. Johns River Phosphorus Load Summary
1995-99

Upstream (Middle St. Johns, Ocklawaha and Crescent Lake
LSJR Basin Nonpoint Source
LSJR Basin Point Source

Dotted - Anthropogenic
Clear - Natural Background
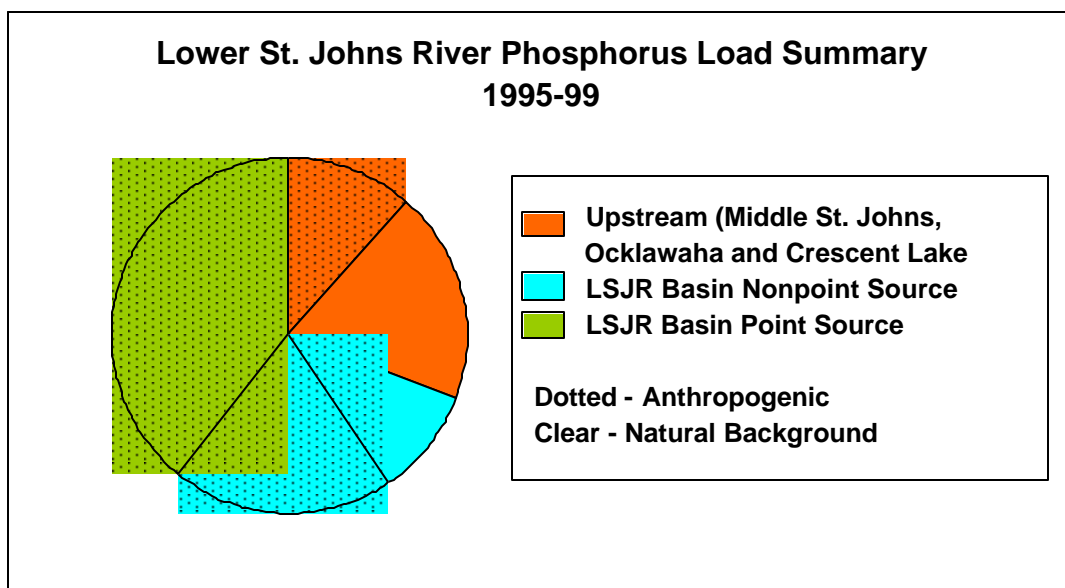
5. DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Use of Modeling

Nutrient enrichment and the resulting problems related to eutrophication tend to be widespread and are frequently manifested distant (in both time and space) from their source. Addressing eutrophication involves relating water quality and biological effects (photosynthesis, decomposition, nutrient recycling, etc.), as acted upon by hydrodynamic factors (flow, wind, tide, salinity, etc.) to the timing and magnitude of constituent loads supplied from various categories of pollution sources. Dynamic computer simulation models have become indispensable tools to describe these relationships. Calibrated models also provide opportunities to predict water quality conditions under alternative constituent loadings.

5.2 Models Used

An inter-connected suite of basin-wide hydrologic, hydrodynamic, and water quality models have been assembled to develop this TMDL. The suite of models includes (a) a hydrologic model that calculates seasonal runoff and nutrient loads for each sub-basin within the LSJRB (PLSM, described previously), (b) a hydrodynamic model of the river that simulates mixing and transport of nutrients within the river, and (c) a water quality model that simulates the transformation of nutrients and processes affecting eutrophication within the river.

River hydrodynamics and salinity of the LSJR were simulated with the Environmental Fluid Dynamics Code model (EFDC) (Hamrick 1992; Sucsy and Morris 2000). EFDC solves finite-differenced forms of the hydrostatic Navier-Stokes equations, together with a continuity equation, and transport equations for salinity, temperature, turbulent kinetic energy, and turbulent macroscale. The equations are solved horizontally on a curvilinear, orthogonal grid and vertically on a stretched, sigma-grid. Figure 7 illustrates the grid used for both the hydrodynamic and water quality models. This grid is composed of 2,210 horizontal cells and six vertical layers. The mean cell length is 492 meters, and the maximum achievable time-step for stability of the hydrodynamics simulation is approximately 30 seconds. With the EFDC application to the LSJR, remarkably precise simulations of tidal range, tidal occurrence, and river flow have been achieved (Sucsy and Morris, 2002).

The three-dimensional, time-variable water quality process model code used was the Corps of Engineers Quality Integrated Compartment Model (CE-QUAL-ICM), Version 2 (Cerco and Cole 1993). CE-QUAL-ICM is among the most sophisticated water quality process models in existence and was originally developed for the Chesapeake Bay Program to examine factors leading to bay hypoxia. Version 1 of the model contained 22 variables that simulated oxygen dynamics and included the interaction of three phytoplankton groups, nutrients, and organic carbon. A benthic sediment diagenesis submodel was dynamically coupled with the water column to produce sediment oxygen demand and nutrient fluxes. In its current version, the model has been expanded to include compartments for benthos, zooplankton, and submerged aquatic vegetation. Table 3 summarizes the variables included in the lower St. Johns River version of the CE-QUAL-ICM model.

Figure 7. Model Cells for the LSJR Modeling

Legend

● LSJRB Flow Entry Points

4 0 4 8 Miles

1:410000
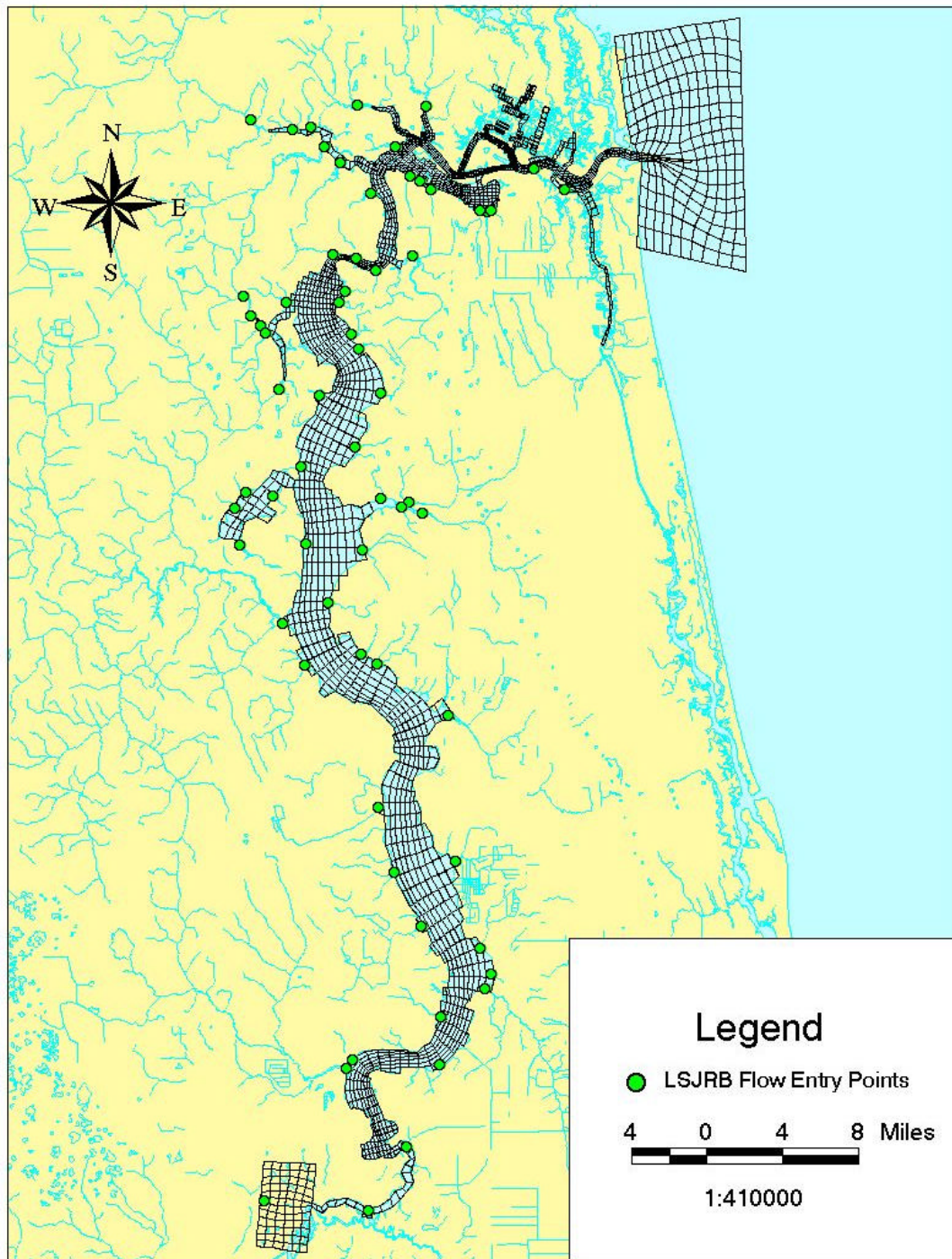
Table 3. Modeled variables included in CE-QUAL-ICM Model.

Model State Variables	
Nitrate + Nitrite Nitrogen	Internal Phosphorus, Algal Group 1
Ammonium nitrogen	Internal Phosphorus, Algal Group 2
Urea	Internal Phosphorus, Algal Group 3
Refractory Dissolved Organic Nitrogen	Refractory Dissolved organic carbon
Labile Dissolved Organic Nitrogen	Labile Dissolved organic carbon
Refractory Particulate Organic Nitrogen	Refractory particulate organic carbon
Labile Particulate Organic Nitrogen	Labile particulate organic carbon
Total Non-volatile Suspended Solids	Green algae biomass as carbon
Dissolved Orthophosphate P	Cyanobacteria biomass as carbon
Particulate Inorganic P	Diatoms biomass as carbon
Refractory Dissolved Non-orthophosphate P	Temperature
Labile Dissolved Non-orthophosphate P	Salinity
Refractory Particulate Non-orthophosphate P	Dissolved oxygen
Labile Particulate Non-orthophosphate P	Available silica
Chemical oxygen demand	Particulate biogenic silica

Sediment Model	
State Variables	Sediment-Water Flux
Temperature	
Particulate organic carbon	Sediment oxygen demand
Sulfide/methane	Release of chemical oxygen demand
Particulate organic nitrogen	
Ammonium	Ammonium flux
Nitrate	Nitrate flux
Particulate organic phosphorus	
Phosphate	Phosphate flux
Particulate biogenic silica	
Dissolved silica	Silica flux
Benthic algal biomass	Dissolved oxygen, nutrients

State Variables for Submersed Aquatic Vegetation	
Deposit feeding benthos as carbon	Filter feeding benthos as carbon
Micro zooplankton as carbon	Meso zooplankton as carbon
SAV shoot biomass as carbon	SAV root biomass as carbon
Epiphyte biomass on SAV as carbon	Inorganic suspended solids
Benthic algae as carbon	

The U.S. Army Corps of Engineers Research and Development Center (USACE-ERDC) applied CE-QUAL-ICM to the LSJR through a combination of modifications to existing subroutines and through the development of new subroutines and state variables, where appropriate. LSJR-EFDC hydrodynamics were linked to CE-QUAL-ICM.

New subroutines were added to the water quality model including processes for photochemical decomposition of colored dissolved organic matter, nitrogen fixation by one of the phytoplankton groups, and a flocculation subroutine to account for transfer of organic carbon from the dissolved to particulate phase at the turbidity maximum. New state variables added included

refractory dissolved organic carbon, nitrogen, and phosphorus. The full sediment diagenesis submodel was utilized and three phytoplankton compartments were simulated (freshwater bluegreen algae, freshwater diatoms, and marine diatoms). Cerco (draft in preparation) documents modifications to CE-QUAL-ICM that were made for this application of the model.

Key recent changes to the oligohaline/mesohaline component of the water quality model included:
- a) separation of the algal communities into a freshwater group and a marine group, with optimum salinities of 5 parts per thousand (ppt) and 20 ppt, respectively.
- b) a 50% increase in the values for KLDC and KLPC, from 0.05/day to 0.075/day.
- c) a 50% reduction in the reaeration rate in the narrow channel from the Acosta Bridge to Mayport, and
- d) revision such that all organic carbon from predation was labile.

5.3 Model Setup

Hendrickson and Konwinski (1998) described the setup of the PLSM to provide daily flows and loads from contributing sub-basins to the St. Johns River. Figure 7 shows points in the hydrodynamic/water quality grid where sub-basin and point source contributions enter. The upstream boundary for the EFDC and CE-QUAL-ICM models was placed at Buffalo Bluff where total daily river discharge is recorded. Water quality measurements are also routinely collected at Buffalo Bluff and were used to define time variable boundary loads. The downstream boundary for the EFDC and CE-QUAL-ICM models included a tidal water level open ocean boundary and a time series of water quality measurements.

5.4 Model Calibration

Suscy and Morris (2002) described the calibration procedure and presented hydrodynamic model results for the January 1, 1995 – November 30, 1998 calibration period. Calibration of the EFDC involved examination and adjustments to the following data and input parameters: bottom bathymetry, bottom roughness, tidal waterlevel at the open ocean boundary, specification of an adequate number of vertical layers, and specification of a non-reflective upstream open boundary. The model was first calibrated for only the M_2 tide, but then the following components were added: (a) low-frequency, subtidal waterlevel at the ocean boundary, b) main stemflow at Buffalo Bluff, (c) dynamically-coupled salinity, (d) tributary inflows, and (e) meteorologic components for wind, rainfall, and evaporation. Error analytical techniques used to compare observed and simulated results are described by Suscy and Morris (2002). These techniques included (a) regression analysis, (b) calculation of median relative error, (c) comparison of means, (d) calculation of root mean square error (RMSE), and Kologorov-Smirnov tests for determining the likelihood that two sample populations have identical cumulative distribution functions.

The calibrated EFDC model was provided to USACE-ERDC for linkage to the modified CE-QUAL-ICM model (June, 2000). The USACE-ERDC was contracted to provide a model calibrated to data collected from the December 1, 1995 through November 30, 1998 period. Once delivered to the SJRWMD, the SJRWMD staff performed skill assessments of the model using data collected outside the calibration period (1995, 1996, and 1999).   Because of the dramatic differences that occurred in the high flow and low flow years of 1998 and 1999, calibration effort was shifted to these two years to better encompass total potential environmental variation.

Calibration and verification results for the water quality model are presented in Sucsy et al. (2003; in preparation), and Cerco (2003; in preparation). Some of the same analytical techniques used to evaluate the hydrodynamic calibration were used to evaluate the calibration of key water quality parameters at long-term monitoring sites. Example results from a RMSE analysis of DO predictions at Acosta Bridge and Dames Point are shown in Appendix E (Figures E1 and E2, respectively), and calibration results for chlorophyll *a* are shown in Appendix F (Figures F1 – F4).

5.5 Model Results Used to Determine Assimilative Capacity

Based upon a recommendation from the Lower St. Johns TMDL Executive Committee, point sources directly discharging to the St. Johns were evaluated based upon their 1997-98 discharge flows and loads, with an allowance for anticipated growth over the next few years (rather than assuming permitted design flows and loads). Table 4 summarizes the starting conditions assumed for each facility that were considered as part of the TMDL process. Nonpoint source contributions to the river varied in response to fluctuations in annual rainfall.

The SJRWMD staff presented results from model simulations for the freshwater zone for 1995, 1997, 1998, and 1999. Each year was evaluated with respect to whether the predicted chlorophyll *a* levels met the alternative chlorophyll *a* threshold of 40 ug/L for less than 10% of the time. Suscy (2003, draft) described the process of assessing the relative influence of anthropogenic nitrogen and phosphorus loads from point, nonpoint, and the upstream boundary by simulating incremental reductions (25%, 50%, 75%, 100% reduction) to the river. Exceedance of the alternative chlorophyll *a* target was calculated for each year along with the estimated reduction in the anthropogenic load necessary to meet the target. Based upon the long-term average results for the four years, the SJRWMD recommended PLRG was a 30% reduction in anthropogenic point, nonpoint, and upstream boundary nitrogen and phosphorus loads.

A similar analysis was completed for the combined oligohaline/mesohaline portion of the river. In these zones, model DO predictions were evaluated to determine whether the "persistent exposure criterion" impairment index (1.0) was met for each set of incremental reductions for each model year. In this portion of the river, nitrogen was the key nutrient that needed to be reduced to meet the target. Due to depressed dissolved oxygen conditions and a large fish kill in 1999, 1999 was selected as the period to establish nitrogen load reductions to protect the ecological health of the aquatic community. The SJRWMD recommended PLRG was a 22% reduction in anthropogenic point and nonpoint nitrogen loads from within this reach. This load reduction was contingent upon the 30% reduction occurring in the upstream, freshwater reach.

Table 4. Starting Point TN and TP Loads for Point Sources

Name of Facility	Current Flow (MGD)	Projected increase (MGD)	Permitted Flow (MGD)	Starting Point Flow (MGD)	1997-98 Nutrients		Starting Point	
					TN (mg/L)	TP (mg/L)	TN (lb/day)	TP (lb/day)
SMURFIT-STONE CONTAINER CORPORATION	6.88	-	20	8.85	6.8	1.1	502	85
JEFFERSON SMURFIT – JAX	-	-	6	6.0	8.8	1.2	441	58
USN - NS MAYPORT WWTF	0.88	0.044	2	1.03	3.2	2.1	27	18
USN - NAS JACKSONVILLE WWTF	0.955	0.048	3	1.13	8.5	1.7	80	16
GEORGIA -PACIFIC	24.49	-	40	34.2	5.5	1.4	1556	385
JACKSONVILLE BEACH WWTF	2.5	0.13	4.5	3.2	9.1	2.2	242	59
NEPTUNE BEACH WWTF	0.744	-	1.5	0.94	8.8	1.4	69	11
GREEN COVE SPRINGS – Harbor Road WWTF	0.514	0.236	0.75	0.75	9.2	2.9	57	18
WESMINSTER WOODS - (Wesley Manor Retirement Village)	0.03	-	0.09	0.050	4.6	2.0	1.9	0.83
ATLANTIC BEACH – BUCCANEER WWTF	0.91	0.13	1.9	1.13	13.4	1.4	127	13
JEA - MANDARIN WWTF	5.88	1.1	7.5	7.0	5.34	2.3	312	134
JEA - MONTEREY WWTF (operated by UWF)	2.66	0.94	3.6	3.6	11.3	1.6	341	49
JEA - HOLLY OAKS WWTF (formerly UWF)	0	0	1	0	8.3	2.1	0	0
JEA - SAN JOSE WWTF (formerly UWF)	1.65	0.60	2.25	2.25	10.0	2.9	188	55
JEA – JACKSONVILLE HEIGHTS WWTF (formerly UWF)	1.07	0.43	2.5	1.62	10.1	2.9	136	40
ORANGE PARK WWTF	1.16	-	2.5	-	-	3.7	150	41
JEA - SAN PABLO WWTF (formerly UWF)	0.58	0.18	0.75	0.75	6.5	3.5	40	22
CCUA - MILLER STREET WWTF	3.54	1.46	4.99	4.99	4.5	3.2	189	133
JEA - ORTEGA HILLS WWTF (formerly UWF)	0.09	0	0.22	0	16.8	2.3	0	0
JEA - BUCKMAN WWTF	32.04	0.96	52.5	34.02	10.5	4.7	2966	1331
JEA - ARLINGTON WWTF	12.86	5.14	20	18	14.3	2.6	2143	393
JEA - NORTHEAST WWTF (fka JEA - DISTRICT II	3.2	1.05	10	5.4	22.7	5.9	1016	263

WWTF)								
JEA - SOUTHWEST WWTF	7.30	4.70	10	10	10.5	1.4	875	116
JEA - ROYAL LAKES WWTF (formerly UWF)	1.64	0.66	3.25	2.99	7.8	3.8	193	94
FWSC - BEACON HILLS SD WWTF	0.66	0.25	1.3	0.99	11.9	2.0	99	16.8
FWSC - WOODMERE SD WWTF	0.43	0.21	0.7	0.64	11.6	1.7	61	8.8
GREEN COVE SPRINGS – SOUTH WWTF	0.21	0	0.5	0.27	13.6	2.3	31	5.3
CCUA - FLEMING OAKS WWTF	0.37	0.03	0.49	0.40	3.0	1.9	10.1	6.5
ATLANTIC BEACH – MAIN WWTF (D001)	1.73	0.07	3	1.8	11.4	2.1	170	31
PALATKA WWTF	2.22	0.35	3	3.0	14.7	2.4	367	60
ANHEUSER BUSCH - MAIN ST - LAND APP	1.46	-	2.6	2.6	3.9	0.3	84	7.6
HASTINGS WWTF	0.085	0.018	0.12	0.103	4.5	0.6	3.9	0.53
JEA - JULINGTEEN CREEK WWTP	0.21	2	0.476	0.476	12.0	3.0	48	12
CCUA - FLEMING ISLAND WWTF (combined)	1.078	-	6.365	-	-	-	172	64
UWF - SAINT JOHNS NORTH WWTF	-	0	n/a	0	6.5	1.7	0	0
BRIERWOOD SD – BEAUCLERC STP	-	0	n/a	0	-	-	0	0

6. DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = ?\ WLAs + ?\ LAs + MOS$$

As mentioned in Section 4.1, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$TMDL\ ?\ ?\ WLAs_{wastewater} + ?\ WLAs_{NPDES\ Stormwater} + ?\ LAs + MOS$$

It should be noted that the various components of the TMDL equation may not sum up to the value of the TMDL because a) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is accounted for within the LA, and b) TMDL components can be expressed in different terms [for example, the WLA for stormwater is typically expressed as a percent reduction and the WLA for wastewater is typically expressed as a mass per day].

WLAs for stormwater discharges are typically expressed as "percent reduction" because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport).   The permitting of stormwater discharges is also different than the permitting of most wastewater point sources.   Because stormwater discharges cannot be centrally collected, monitored and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the "maximum extent practical" through the implementation of Best Management Practices.

This approach is consistent with federal regulations [40 CFR § 130.2(I)], which state that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or **other appropriate measure**. TMDLs for the LSJR are expressed in terms of kilograms per year, and represent the maximum annual TN and TP load the fresh and estuarine reaches of the river can assimilate and maintain the narrative nutrient criterion (Tables 5 and 6). As noted in Table 6, the TMDL for the estuarine portion of the river is for TN only because nitrogen is the limiting nutrient for this portion of the river.

While neither the WLA or LA are broken into individual sources or source categories, the division of the available assimilative capacity between the WLA and LA was determined using information about individual sources and source categories. The allocation methodology followed the recommendations in the 2001 Report to the Governor and Legislature on the Allocation of Total Maximum Daily Loads (Department, 2001). Under this approach, initial reductions for the river were targeted at nonpoint source loads assuming implementation of Best Management Practices (BMPs). As BMP implementation alone did not result in sufficient reductions, all anthropogenic sources, including the upstream load, were reduced by the same percentage until the assimilative capacity was met, with the exception that prior treatment or prior commitments in treatment improvements were taken into account for individual point sources. Allocation calculations were conducted using an Excel spreadsheet, and table versions of the spreadsheets used to allocate loadings in the freshwater and estuarine portions of the river are provided in Appendix G (interested parties can request an electronic copy of the spreadsheet if they would like to see spreadsheet formulas).

Table 5. TMDL Components for the Freshwater Portion of the LSJR

WBIDs	Parameter	TMDL (kg/year)	WLA[3] (kg/year)	LA (kg/year)	MOS
2213I to 2213M	Total Nitrogen	8,570,260	207,347	8,362,913	Implicit
2213I to 2213M	Total Phosphorus	500,325	41,097	459,228	Implicit

Table 6. TMDL Components for the Estuarine Portion of the LSJR

WBIDs	Parameter	TMDL (kg/year)	WLA (kg/year)	LA (kg/year)	MOS
2213A to 2213H	Total Nitrogen	1,472,984	1,112,480	360,504	Implicit

The combined WLA is designed to allow flexibility so that reductions from one discharger can be shifted to another as long as the net reduction reaches the TMDL. However, it should be noted that the objective of the TMDL Program is to eventually allocate loads among all of the known pollutant sources throughout the watershed so that appropriate control measures can be implemented and water quality standards achieved. As such, a more detailed allocation of the TMDL will be determined as part of the development of the implementation plan for this TMDL (termed the Basin Management Action Plan). Individual WLAs will take into account the existing treatment levels and economic feasibility and location of dischargers, and individual WLAs will be encoded in the facility's NPDES permit. Reductions required to meet allocations to nonpoint sources will be voluntary, but will be aggressively pursued by multi-agency and stakeholder efforts.

6.2 Load Allocation

The LA for the freshwater portion of the LSJR includes the following loads: a) the natural background nonpoint source load (which includes background upstream loads from the Middle St. Johns River (MSJR) and background loads from Dunns Creek), b) augmented nonpoint source loads (again including augmented upstream loads from the MSJR and Dunns Creek), and c) atmospheric deposition. To determine the allocation between the WLA and LA, the augmented TN and TP nonpoint source loads were first reduced by the amounts estimated for implementation of applicable BMPs on agricultural lands and urbanized areas, and then augmented nonpoint sources (excluding atmospheric deposition) and point sources were reduced by the same percentage until the assimilative capacity was met. Using this approach, the LA takes into account reductions expected in the upstream load from the MSJR. However, the LA does NOT take into account changes in nonpoint source loads due to projected changes in land use. Any increase in nonpoint source loads due to growth will need to be addressed in the B-MAP for the LSJR Basin. It should also be noted that the LA includes loading from

---

[3] As described in Section 6.2, this WLA includes a percent reduction in current loading from sources covered by the NPDES Stormwater Program.

stormwater discharges regulated by the Department and the Water Management Districts that are not part of the NPDES Stormwater Program (see Appendix F).

6.3 Wasteload Allocations

The WLA for the estuarine portion of the river is a combination of the sum of the WLAs for all of the NPDES wastewater facilities and the stormwater discharge from the Duval County Municipal Separate Storm Sewer System (MS4). To estimate the load from the Duval County MS4, the urban stormwater component of the nonpoint source loads to the estuarine portions of the river were moved from the nonpoint source inventory to the WLA. Consistent with the recommended allocation methodology, the TN load estimated for urban nonpoint sources was reduced by the expected reduction that would be achieved through implementation of stormwater BMPs in 90% of the urbanized area.

The WLA for the freshwater portion of the river is the sum of the WLAs for all of the NPDES wastewater facilities and a percent reduction assigned to stormwater discharges subject to the Department's NPDES Stormwater Program. The WLA includes this percent reduction for stormwater discharges because, based on the 2000 census, the watershed of the freshwater portion of the LSJR includes areas that are covered by the MS4 Program. The WLA for stormwater discharges is a 34.5 percent reduction in current TP loading and a 15.3 percent reduction in current TN loading from the MS4. It should be noted that any MS4 permittees will only be responsible for reducing the loads associated with stormwater outfalls for which it owns or otherwise has responsible control, and is not responsible for reducing other nonpoint source loads within its jurisdiction.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (2001), an implicit margin of safety (MOS) was assumed in the development of this TMDL. An implicit MOS was provided by the conservative decisions associated with a number of modeling assumptions, development of site-specific alternative water quality targets, and development of the assimilative capacity.

In the freshwater zone, multiple years of phytoplankton and zooplankton field measurements were evaluated to establish the site-specific chlorophyll *a* level beyond which zooplankton abundance and diversity started to decline. Hydrodynamic/water quality simulations over four different years were then evaluated to determine the appropriate long-term average TN and TP load reductions necessary to meet the chlorophyll *a* target. These four years represent flows that were slightly drier than average conditions and, given that the effects of nutrient impairment are more prominent in dry conditions, this long-term, yet dry period is considered conservative.

The expression of the TMDLs also provided an implicit MOS because equal percent reductions of both TN and TP were required even though both nutrients may not be the limiting factor for a given year in the freshwater zone. In addition, reductions were based upon meeting the target within all five WBIDs in the freshwater zone. As such, the "worst case" WBID controlled the amount of reduction needed. Finally, point source flows and loads used in the WLA for the freshwater zone were based upon existing flows and loads with an allowance for growth rather than assuming permitted limits. An implicit MOS is provided by this approach because it would

be extremely unlikely that all of the point sources would simultaneously discharge at their full WLA.

Conservative assumptions were also part of the development of the TMDL for the oligohaline/mesohaline portion of the river. As in the freshwater zone, four different years were simulated. However, in this case, the worst case year (1999) was used to establish necessary nitrogen load reductions in the oligohaline/mesohaline zone because the controlling factor, DO, can result in impairment in shorter time frames than increased algal biomass. In 1999, there were reduced rainfall and increased residence times, which resulted in reduced DO levels and a large fish kill. As in the freshwater zone, the percent reduction needed for the oligohaline/mesohaline zone was based upon ensuring that the target was met in all of the WBIDs in these zones.

Another conservative assumption involved the use of the dissolved oxygen minimum threshold from the EPA ambient dissolved oxygen (saltwater) Cape Cod to Hatteras document (1999). The document specifies that the criteria are limited to the Virginian Province but that the approach is applicable to regions outside the Virginian Province. It is likely that a number of species in this warmer, more temperate/semi-tropical province have adapted to a lower DO threshold before adverse growth or reproductive impacts occur.

Finally, point source flows and loads used in the WLA for the oligohaline/mesohaline zones were based upon existing flows and loads with an allowance for growth rather than assuming permitted limits. As noted previously, an implicit MOS is provided by this approach because it would be extremely unlikely that all of the point sources would simultaneously discharge at their full WLA.

6.5 Seasonal Variability

Seasonal variability was assessed during the development of this TMDL as part of the development the site-specific water quality targets and the determination of the assimilative capacity. The site-specific targets developed for the freshwater and oligohaline/mesohaline zones account for the seasonal cycles in algal growth. In the freshwater zone, the critical period occurred during April – August when excessive algal growth has led to imbalances in the algal community structure (dominance by only a few species) and impacts to the food web (undesirable prey for zooplankton and fish species). The chlorophyll *a* target for the freshwater zone (40 ug/L not to be exceeded more than ten percent of the time) was specifically designed to prevent algal blooms of sufficient duration to cause these imbalances in flora and fauna in the future.

The TMDL for the oligohaline/mesohaline zone also accounted for seasonal variability. As discussed earlier in the MOS section, the summer period of 1999 was a critical period during which dissolved oxygen was below 4.0 mg/l at levels and for durations that could adversely impact the aquatic fauna in the oligohaline/mesohaline zones. The method used to develop the DO target accounted for these critical, seasonal (and diurnal) periods and ensures that excursions of DO levels below the chronic threshold will not occur at a magnitude or duration that would result in impacts to the aquatic fauna.

7. NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

Following adoption of this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, which will be a component of the Basin Management Action Plan for the Lower St. Johns River Basin. This document will be developed in cooperation with local stakeholders and will attempt to reach consensus on more detailed allocations and on how load reductions will be accomplished.

The Basin Management Action Plan (B-MAP) will include:
- Appropriate allocations among the affected parties.
- A description of the load reduction activities to be undertaken.
- Timetables for project implementation and completion.
- Funding mechanisms that may be utilized.
- Any applicable signed agreements.
- Local ordinances defining actions to be taken or prohibited.
- Local water quality standards, permits, or load limitation agreements.
- Monitoring and follow-up measures.

It should be noted that TMDL development and implementation is an iterative process, and this TMDL will be re-evaluated during the BMAP development process and subsequent Watershed Management cycles. The Department recognizes that it may be appropriate to revise the TMDL in the future when more information has been collected and analyzed. With such possible revisions in mind, this TMDL is characterized as an adaptive management TMDL. In an adaptive management TMDL, the Department used the best available information at the time to establish an interpretation of their narrative nutrient standard to derive the water quality end point as the basis for the TMDL. However, the adaptive management approach recognizes that additional data and information may be necessary to validate assumptions of the TMDL, specifically the interpretation of the nutrient narrative criterion as 40 ug/L chlorophyll a not to be exceeded more than 10% of the time, and to provide greater certainty that the TMDL will achieve use support of the St. Johns River and prevent an imbalance in natural populations of aquatic flora and fauna. If any changes in the estimate of the assimilative capacity AND/OR allocation between point and nonpoint sources are required, the rule adopting this TMDL will be revised, thereby providing a point of entry for interested parties.

REFERENCES

Adamus, C.L. and M.L. Bergman. 1995. Estimating nonpoint source pollution loads with a GIS screening model. Water Resources Bulletin 31(4):647-655.

Burkholder, J.M. and H.B. Glasgow, Jr.. 1997a. *Pfiesteria piscicida* and other *Pfiesteria*-like dinoflagellates: Behavior, impacts, and environmental controls. Limnology & Oceanography 42(5, part 2):1052-1075.

Burkholder, J.M. and H.B. Glasgow, Jr.. 1997b. Trophic controls on stage transformations of a toxic ambush-predator dinoflagellate. J. Euk. Microbiology 44:200-205.

Cerco, C, and T. Cole. 1993. Three-dimensional eutrophication model of Chesapeake Bay. Journal of Environmental Engineering. 119:1006-1025.

Department of Environmental Protection. February 2001. A Report to the Governor and the Legislature on the Allocation of Total Maximum Daily Loads in Florida. Bureau of Watershed Management.

Department of Environmental Protection. 2002. Basin Status Report for the Lower St. Johns River Basin. Bureau of Watershed Management.

EPA. September 1999. Ambient Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras. Office of Water Office of Science and Technology. EPA 822-D-99-002. 55pp.

Hamrick, John.M. 1992. A three-dimensional environmental fluid dynamics computer code: Theoretical and computational aspects. Special Report 317. The College of William and Mary, Virginia Institute of Marine Sciences, Virginia.

Hendrickson, J. and J. Konwiniski. 1998. Seasonal Nutrient Import-Export Budgets for the Lower St. Johns River, Florida. St. Johns River Water Management District.

Hendrickson, J. and W. Magley. 2001. Development of Total Maximum Daily Loads and Pollution Load Reduction Goals for the Lower St. Johns River Basin: Plan of Study. St. Johns River Water Management District.

Hendrickson, J.C., N. Trahan, E. Stecker, J. Richarde and Y. Ouyang. 2002. Temporal and Spatial Patterns in the External Carbon, Nitrogen and Phosphorus Load to the Lower St. Johns River for the Fulfillment of TMDL and PLRG Requirements. Water Resources Department Technical Memorandum No. __, St. Johns River Water Management District, Palatka, FL.

Hendrickson, J.C., E.F. Lowe, D. Dobberfuhl and D. Campbell. 2003. Accelerated Eutrophication in the Lower St. Johns River Estuary and Recommendation of Targets for the Achievement of Water Quality Goals to Fulfill TMDL and PLRG Objectives. Water Resources Department Technical Memorandum No. __, St. Johns River Water Management District, Palatka, FL.

Phlips, E.J., M. Cichra, F.J. Aldridge, J. Jembeck, J. Hendrickson, and R. Brody. June 2000. Light availability and variations in phytoplankton standing crops in a nutrient-rich blackwater river. Limnology & Oceanography 45:(4) 916-929.

SJRWMD, January 1993. SWIM Plan for the Lower St. Johns River. St. Johns River Water Management District, Palatka, Florida.

Sucsy, P.V. and F.W, Morris. 2002. Calibration of a Three-dimensional Circulation and Mixing Model of the Lower St. Johns River. Technical Memorandum No. xx Draft 1.1. St. Johns River Water Management District.

Sucsy, P., and J. Hendrickson. 2003. Eutrophication Modeling of the Lower St. Johns River Estuary to Establish the TMDL and PLRG Assimilative Capacities for Nitrogen and Phosphorus.   Water Resources Department Technical Memorandum No. __, St. Johns River Water Management District, Palatka, FL.

Appendix A
The Lower St. Johns River Basin TMDL Executive Committee

This broad-based group was convened by the Department of Environmental Protection's Northeast District and has been meeting since July 2002. It has advised the Department on such issues as water quality targets and allocation processes. The Committee will play a critical role in the development of the Basin Management Action Plan to implement TMDLs. The Committee membership as of July 2003 is listed below:

Lower SJR Basin TMDL Executive Committee	
Interest Group	Representative
Dept. of Environmental Protection	Mario Taylor, Northeast District (Chair)
Industry	Mike Burch, Plant Manager, Rayonier
Agriculture	Wayne Smith, President, North Florida Growers Exchange
Builders	Neil Aikenhead, Northeast FL Builders Association
Utility Authorities	Susan Hughes, JEA
Environmental Interest Groups	Roger Bass, St. Johns River Keeper
	Don Loop, Stewards of the St. Johns River
Regional Planning Council	Brian Teeple, NE Florida Regional Planning Council
Forestry	Jim Kuhn, Shadow Lawn Farms
Local Government	Honorable Glen Lassiter, Clay County Commission
Dept. of Agriculture & Cons. Services	Jody Lee, DACS
MSW – Public Works	Ed Hall, City of Jacksonville Public Works
St. Johns River WMD	Casey Fitzgerald (for Executive Director Kirby Green)
U.S. Army Corps of Engineers	Richard Bonner, USACOE

LSJR Executive Committee Mission Statement

The Lower St. Johns River TMDL Executive Committee advises the Department of Environmental Protection on the development and implementation of Total Maximum Daily Loads (TMDLs) for the basin. The Committee represents and communicates with key stakeholders to secure local input and consensus on pollutant reductions. The Committee is charged with recommending a "reasonable and equitable" allocation of pollutant load reductions for achieving TMDLs in the lower basin and, in conjunction with the Department, developing a basin management action plan to implement those load reductions.

Appendix B
Eutrophication Defined

Eutrophication can be generally described as a process of changing the ecological status of a water body by increasing the baseline (e.g., primary) level of productivity, almost invariably a result of increasing nutrient supply. Some researchers (Nixon 1995) have suggested that estuarine eutrophication be defined as "an increase in the rate of supply of organic matter to an ecosystem," as the effect of eutrophication in most systems is an increase in plant (algae and/or nuisance aquatic plants) biomass.

The general sequence of eutrophication effects is as follows. In the enrichment phase, there is an episodic or continuous increase in algal and plant biomass. Above a certain level of nutrient availability, changes in plant species composition occur which can have profound effects on the habitat and structure of the rest of the food web, potentially affecting energy flow in the entire ecosystem. Secondary effects can include reductions in light penetration that can reduce the species composition and depth distribution of benthic plants, increased probability of the occurrence of toxic/nuisance phytoplankton blooms, hypoxia (commonly used to describe DO concentrations at or below 2.0 mg/L), and behavioral effects on other organisms in the food web (Gray 1992). Extreme effects can include mass growth of undesirable plants, regular blooms of toxigenic and other nuisance algae, and, ultimately, migration or mortality of various species.

Appendix C

**Basis for LSJR Water Quality Targets
(Excerpts[4] from Hendrickson Draft Document,
Chapter 2. Characteristics of Algal Growth Within the Lower St. Johns River)**

---

[4] Only text was excerpted. Figures and tables referenced in the text are available from the SJRWMD.

Water Quality Targets for the LSJR

Some measure of the three most commonly identified water quality effects of estuarine eutrophication—nuisance levels of algal biomass, reduced dissolved oxygen and reduced transparency—were recommended in the original Plan of Study (POS) document as the response variables in establishing nutrient TMDLs and PLRGs for the LSJR. These TMDL and PLRG targets were originally established consistent with standards or thresholds set forth in Chapter 62-302, *F.A.C.*, and Chapter 62-303, *F.A.C.* However, in the process of data analysis and investigation to describe nutrient enrichment effects and to quantify these relationships through water quality modeling, these targets have undergone refinement in order to more closely address the most problematic aspects of eutrophication in the LSJR.

Relevant questions driving the re-definition of targets were:
1) Is the dissolved oxygen State standard sufficiently protective, or conversely, unnecessarily protective, for biota endemic to the LSJR?
2) Is the maintenance of transparency, based upon open water changes in compensation depth, relevant to SAV colonization in the LSJR?
3) Do algal biomass targets, based upon mean annual chlorophyll *a* concentrations, sufficiently address the most problematic aspects of nuisance algal blooms?

Because of the weak linkage between open water, planktonic algal attenuation that is embodied in the transparency standard as stated in Chapter 62-302, F.A.C., and the more realistic case of epiphytic algal attenuation for littoral submerged grasses, it was felt that the transparency criteria is not the appropriate target for protection of SAV in the LSJR. Investigations relating nutrient enrichment effects to SAV health, and the interactions between natural factors of light, color and substrate and nutrient enrichment are ongoing and can be used to revise the LSJR nutrient TMDL if warranted.

In light of the great amount of research in support of oxygen criteria, and the recent work accomplished in compiling and refining this research in EPA's *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras*, it was felt that sufficient effort could not be mustered, nor was warranted, to refute these recommendations for the LSJR TMDL.   Therefore, methodologies provided in this guidance have been relied upon for establishing algal biomass targets for the predominantly marine reach of the river. While these methods apply a less restrictive criteria for maintenance of aquatic life based on dissolved oxygen than the current Florida Water Quality Standard, they are arguably more realistic given the natural stressors to oxygen level in a southern temperate blackwater river estuary.

And finally, as experimental evidence suggests that the greatest level of harm from algal blooms occurs from extreme bloom events, the chlorophyll *a* targets for the LSJR were redefined to emphasize the reduction of high concentration and long duration events.

LSJR Freshwater Phytoplankton Community Composition Dynamics and Zooplankton Interactions

The fundamental objective for LSJR TMDL and PLRG nutrient load reduction modeling was the enhancement of plankton ecology for both freshwater and marine environments. This approach was taken because 1) the LSJR is largely a plankton based system, with

the majority of its autochthonous carbon produced through phytoplankton primary production, and 2) a large database composed of five years of phytoplankton and zooplankton monitoring data exists for the LSJR, representing the most powerful biological evaluation tool available.

For the freshwater river, three elements of plankton ecology were assessed:
1) What maximum levels of algal biomass maintain diversity in the plankton community?
2) What maximum levels of algal biomass, or what phytoplankton community composition, facilitates the upward transfer of planktonic primary production to higher trophic levels?
3) What levels of algal biomass minimize the potential for the expansion of detrimental algal species or the production of algal toxins?

Freshwater LSJR Algal Biomass Target

Maintenance of Phytoplankton Diversity

The maintenance of organism diversity is a fundamental goal of biological restoration. Diversity in biological systems promotes stability; conversely, ecosystems with narrow species diversity are prone to large perturbations in communities. The loss of phytoplankton diversity, and the dominance of cyanobacteria during the spring and summer growth seasons is one of the most conspicuous aspects of freshwater blooms of the LSJR. As total phytoplankton community biomass (expressed as chlorophyll *a*) increases, the fraction of the total community biomass composed of blue-greens (determined from biovolume estimates) increases (Figure 27). Blue green relative composition is variable and often low for chlorophyll *a* concentrations to about 40 mg/m^3. After this point, blue green biomass represents the majority of phytoplankton community composition. At chlorophyll *a* concentration above 60 mg/m^3, blue green relative abundance is regularly between 80 to 90 percent.

Facilitation of Upward Trophic Transfer of Primary Production

In its Chesapeake Bay Water Quality Criteria Guidance Manual, EPA outlines an approach to the development of chlorophyll *a* criteria for the purpose of enhancing the upward transfer of phytoplankton carbon to the zooplankton community. The conceptual model utilized in the Chesapeake Bay (CB) Guidance relating mesozooplankton response to increases in algal biomass is depicted in Figure 28. This model is based on the premise that at low to moderate phytoplankton densities, zooplankton populations respond favorably and increase with increase in algal biomass associated with increase in food supply. At some point, however, the increase in toxic or otherwise unpalatable taxa in the phytoplankton community, and an increase in feeding effort due to the density of unfavorable species, leads to a leveling off and perhaps even decline in the desirable zooplankton. The point of the departure from the linear increase in zooplankton – phytoplankton biomass represents the maximum desirable algal biomass.

Plankton monitoring data (Nov. 1996 through Oct. 2001) were examined to determine if a relationship similar to that described above existed for the freshwater LSJR. The zooplankton – algal biomass relationship is shown in Figure 29. Desirable zooplankton

in these graphs are estimated by summing the organism counts for copepods and cladocerns only. Rotifers are excluded, as they are believed to be feeding on small detrital particles and bacteria, and are not believed to be as important a group of zooplankters in supporting the upward transfer of carbon to the fish community. Although a good deal of spread exists in this graph in zooplankton abundance at low to moderate chlorophyll *a* concentration, it is possible to discern a pattern that matches the conceptual model forwarded by the CB guidance.

This graph suggests that the linear increase in zooplankton abundance with increasing chlorophyll *a* concentration begins to decline somewhere between chlorophyll *a* concentrations of 40 to 60 mg/m^3. The adverse response of zooplankton numbers to high levels of algal biomass can be seen in Figure 29 for the specific case of the severe algal blooms that occurred at Racy Point in 1999. At this station, zooplankton numbers increase initially as chlorophyll concentration increases, but then decline as chlorophyll continues to increase. This pattern is repeated for the year's second bloom, which peaks in late August.

<u>Algal Toxin Formation Potential</u>

In recently completed work, Paerl and Charmichael (2002) examined levels of the algal toxins microcystin, anatoxin, and cylindrospermopsin in nutrient enrichment assays performed on LSJR samples collected from October 2000 through August 2001. All toxins were detected during the sampling, with microcystin present in every assay. Microcystin was found to be positively correlated to chlorophyll *a* (e.g., algal biomass), and this relationship is shown in Figure __. Generally, microcystin levels remained low for chlorophyll a concentrations below 40 µg/L. Above this level, microcystin levels were found to be variable, but on occasion reached very high levels, near the World Health Organization standard for drinking water of 1 µg/L. The LSJR is not a drinking water source, and relevance of this standard for the protection of aquatic life has not been quantified. However, the result of these assay experiments suggests that at concentrations of chlorophyll *a* that exceed 40 µg/L, the potential for the appearance of microcystin in ambient water increases greatly.

Algal Bloom Duration

Plankton monitoring data and algal toxin assays indicate that blue green algal blooms of the LSJR freshwater reach begin to exhibit detrimental effect as bloom biomass, measured as chlorophyll *a*, exceeds 40 mg/m^3. These effects would not be expected to be instantaneous at concentrations above 40 mg/m^3, but instead to require some level of duration and intensity. When the numbers of copepods and cladocerans (again, considered to be an indicator of beneficial zooplankton) in plankton sampling are compared to the durations of above 40 mg/m^3 chlorophyll *a* excursions (Figure 30), it can be see that as durations exceed 40 days, copepods and cladoceran numbers are noticeably reduced. In the duration analysis of Figure 10, between 20 to 45 percent of blooms within the freshwater reach exceeded this duration.

The mean duration of above 40 mg/m^3 episodes is between 20 to 30 days within the freshwater reach (Figure 10), but bloom duration increases disproportionately as blooms exceed 30 days. For example, the increase in duration from the 40th percentile bloom to the 50th percentile is approximately 10 days, while the increase from the 50th to the 60th percentile event is on the order of 20 days. When the maximum concentration of blooms

is compared to the bloom duration (Figure 31), the maximum concentrations (based on the linear regressions) corresponding to 40-day durations range between 50 to 74 mg/m^3 chlorophyll *a*. Using the Racy Point station data, it is possible to parameterize a new distribution of chlorophyll *a* that hypothetically would meet the conditions for the maintenance of phytoplankton and zooplankton diversity. This was done by proportionally scaling the synthesized statistical distribution of the existing data (shown in Figure 32 by the dark navy blue line; the natural log of chlorophyll *a* is used to normalize the distribution) to form a new distribution (Figure 32 light blue line) for which the 1 percentile occurrence was the same as the observed data, and the 99th percentile occurrence ($p = 0.01$ for a one tailed test) was equivalent to a chlorophyll *a* of 74 mg/m^3. This synthesized distribution had a mean of 20.1 mg/m^3, a variance of 0.56 mg/m^3, and a 10.6 percent occurrence rate for chlorophyll *a* concentrations greater than 40 mg/m^3.

Marine LSJR Dissolved Oxygen Targets

Dissolved Oxygen Effects

As demonstrated in the previous section outlining eutrophication effects, low dissolved oxygen excursions (persistent episodes below the State criteria of 5 mg/L) occur in both the freshwater and oligo/mesohaline reaches of the LSJR. These excursions occur coincident with high summertime temperatures, and appear to be associated with the decline or crash of significant algal blooms, and on an inter-annual basis are correlated with mean spring-summer algal biomass levels. The improvement of the dissolved oxygen regime for the river and estuary was one of the originally stated objectives of the TMDL and PLRG plan for the river, and the State standard of 5 mg/L (instantaneous for freshwater reaches, and as a daily average for predominantly marine reaches) was identified as the target on which to base nutrient reduction scenario modeling. Even at the time of the proposition of this target, however, considerable uncertainty existed regarding its appropriateness and achievability. Low dissolved oxygen episodes have long been known to occur in southeast U.S. estuaries (Schroeder and Wiseman, 1988), and naturally low dissolved oxygen concentrations are known to be a feature of blackwater river systems. For these reasons, effort has been directed toward refining oxygen regime targets that are based upon the minimum levels necessary for the protection of native estuarine aquatic communities.

As an alternative to the fixed standard of 5 mg/L, the procedure described in the recently published U.S. Environmental Protection Agency Guidance, *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hattaras*, (U.S. EPA, 200) has been used to define the dissolved oxygen target on which reductions of nutrient enrichment effects are to be based. The *Guidance* contains several elements that offer superiority over the oxygen standard of *F.A.C.* 62-302. First, it is based upon the tolerance of low oxygen by estuarine fish and invertebrates, as opposed to both fresh and saltwater species. Second, the *Guidance* establishes an absolute minimum oxygen level for the protection of most estuarine species against acute low concentrations that result in organism mortality, and distinguishes this level from a sub-lethal range that results in reductions in growth and recruitment, and with this, presumably fish health and survival probability. Fish community effects within this sub-lethal range are based upon the intensity and duration of hypoxic events. Third, the *Guidance* offers approaches for assessing effects of two common types of low dissolved oxygen common to eutrophic estuaries: persistent, low dissolved oxygen associated with

late season algal bloom decline; and diurnal patterns of low oxygen associated with high algal standing stock photosynthesis and respiration cycles or tidal transport of low oxygen water masses. In the LSJR, the most common and severe low oxygen episodes are long term, persistent events associated with late season algal community decline, and the *Guidance* procedure for assessing these types of events has been used to define oxygen targets.

Organism Acute Oxygen Levels

The data set used in the *Guidance* to develop criteria minimum concentration (CMC) was assimilated from previous studies that examined species or genus-specific survival under continuous low dissolved oxygen exposures. These studies covered 12 invertebrate and 11 fish estuarine species, mostly at juvenile life stages. The Florida Marine Research Institute's Fisheries Independent Monitoring Program (FMRI, 2001) has confirmed the presence of five of these species in the northeast Florida region (includes one site in the St. Mary's River, one in the Nassau, and 3 in the lower St. Johns estuary), and these are listed in Table 4. Because the FMRI sampling is performed using river seines, haul seines and otter trawls, some benthic invertebrate species may be under-reported. A trend is evident between the numbers of individuals of a given species present in the FMRI sampling, and their low oxygen LC50, in that as an individual species low dissolved oxygen tolerance decreases, its abundance declines in the northeast Florida sampling region (Figure 33). A numbers of factors could account for this, including species natural ranges, sampling methodology, migration patterns or competitive interactions, though the possibility that these species are excluded due to prevailing low dissolved oxygen, either as a natural occurrence or through accelerated eutrophication, should be considered as a contributing factor.

Following the procedure established in the development of toxics criteria, the CMC is determined by adjusting upward LC50 data to estimate the LC5 concentration, using the mean LC5/LC50 ratio for all studies, applied to the most sensitive species mean acute value (SMAV). In the studies compiled in the *Guidance*, pipe fish (*Syngnathus fuscus*), exhibited the highest SMAC, at an LC50 concentration of 1.63 mg/L. Pipe fish was reported in northeast Florida region in the FMRI sampling, but in only one sampling event. For spot (*Leiostomus xanthurus*) the most commonly seen species in the northeast Florida region for which a SMAV is reported, the *Guidance* lists a SMAV of 0.70 mg/L, considerably lower that that of pipe fish. Following the approach used in toxics criteria development, the *Guidance* uses the mean LC5/LC50 ratio, here given as 1.38, to adjust upward the maximum tolerable acute value. Thus the CMC that is considered as protective of most species is give as 2.3 mg/L, and this value has been used for the assessment of low dissolved oxygen effects in the LSJR estuary.

Growth Effects

To develop a measure of sub-lethal effects due to low dissolved oxygen, the *Guidance* relied upon previous studies that examined reductions in fish growth, usually during larval or juvenile life stages, due to low dissolved oxygen concentration. Growth is usually more sensitive than survival to low dissolved concentrations, though the

Guidance notes several exceptions in which studies report greater rates of mortality than growth reduction. In general, invertebrates exhibit low acute dissolved oxygen concentrations, but a large range in growth reduction. Fish, on the other hand, exhibit higher acute concentrations but a relatively narrow range in growth reduction, and it is not unusual for fish species to exhibit considerable overlap in oxygen levels that cause mortality and growth reduction. Based upon a smaller number of studies that reported similar reductions in reproductive success at low dissolved oxygen levels, the *Guidance* concluded that oxygen levels that are protective of growth effects would also likely be protective of reproductive success.

Of the 11 species for which growth effects data were found, 2 were collected in FMRI sampling: summer flounder (*Paralichthys dentatus*), a total of 9 individuals collected, and sheepshead minnow (*Cyprinodon variegates*), a total of 3 individuals collected. One of the most commonly caught fish in the FMRI sampling, silverside (*Menidia* spp.), at 10,342 individuals collected, is also listed in the Guidance growth effects data, though specifically for *Menidia menidia*, Atlantic silverside. The reported no observed effects levels (concentrations above which one would expect no reduction in growth) for summer flounder, sheepshead minnow, and Atlantic silverside are 4.39 – 7.23, 2.5 – 7.5, and 3.9, respectively. Based upon these ranges, it appears that the final chronic value (FCV) at which low dissolved oxygen is not expected to effect growth of 4.8 mg/L is appropriate for northeast Florida.

Larval Recruitment

To estimate the effects of hypoxic conditions at concentrations between 2.3 and 4.8 mg/L, the *Guidance* applies a larval recruitment model to estimate the number of individuals that are "recruited" from early life stages to juvenile stage. This model is based upon larval development time, larval season, attrition rate and patterns of vertical distribution. Nine genus had sufficient data to parameterize the model as developed in the *Guidance*. Two of these, *Menidia* and *Scianops*, are known to be present in northeast Florida based upon the FMRI sampling. The model develops recruitment curves based on the intensity and duration of low dissolved oxygen, and genus-specific curves for the two species found in northeast Florida developed the lowest and third lowest curves (Figure below from *Guidance*).

The larval recruitment model can be adapted with regionally specific data. However, due to lack of specific data for northeast Florida species, and the possibility that species that have not been collected in the FMRI sampling program have been excluded due to human-induced changes in oxygen regime, the model formulation as provided in the *Guidance* has been used for the LSJR TMDL/PLRG process.

Additional Considerations

The methodology descried in the EPA estuarine dissolved oxygen guidance addresses only acute and chronic (growth) direct effects from low dissolved oxygen. Because of predator-prey interactions, the timing of reproductive activities, additional stressor effects under conditions of nutrient enrichment and eutrophication, direct effects may be

DRAFT

mitigated or enhanced. Breitburg (2002), in her review of hypoxia effects on coastal fisheries, addresses many of the permutations of trophic alterations that may potentially occur.

While the approach used is expected to be appropriate for other regions outside the Virginian Province estuaries, the *Guidance* does note that animals may have adapted to lower oxygen levels in regions of higher temperatures or with naturally high demands for dissolved oxygen. In particular, it may be appropriate at some point to develop regionally specific data for revising the larval recruitment model on which cumulative, sub-lethal effects are based. However, based upon the presence of species in northeast Florida that have been shown to exhibit reduced growth in the range of dissolved oxygen between 4 and 5 mg/L, and the possibility that certain species that are not shown to be present in this region from the FMRI sampling have been excluded due to human-induced reductions in dissolved oxygen, it is felt that the larval recruitment model represents a conservative estimate of potential harm that is less restrictive that the application of a strict 5 mg/L standard.

Application of the Criteria

The maximum acute value, growth effects threshold and larval recruitment model are combined into one relationship relating the intensity and duration of a given continuous, low dissolved oxygen event. This approach is graphically depicted in Figure 34. Above 4.8 mg/L, pelagic, estuarine organisms are assumed to suffer no chronic effect from hypoxia (defined as dissolved oxygen below saturation concentration; oxygen saturation concentration at 30 ^{o}C and 15 ppt chlorinity = 6.5 mg/L). Oxygen levels below 2.3 mg/L are expected to have acute lethal effects to at least some organisms. Between these two values, the degree of mortality in the population is proportional to the duration of exposure, and the compilation of data from numerous dose-response studies was used to develop the relationship seen in this figure. A given interval of low dissolved oxygen is considered to be a "dose" of potentially low dissolved oxygen, and is expressed as the fraction of the total duration of the interval at that concentration needed to cause mortality in at least 5% of the most sensitive species of the fish community. For example, the impairment index calculated duration of exposure to dissolved oxygen at 3 mg/L is 5.57 days. A one day duration of 3 mg/L dissolved oxygen is considered to be 1/5.57 or 18% of a lethal dose. Individual doses of continuous exposure that sum up to greater than 1 are considered to be a lethal dose.

Following the approach, 3 out of the 6 years of data collected at the Dames Point station exhibited one, long excursion of continuous low D.O., with durations from 4 to 7 weeks. Calculated impairment scores for Dames Point were 1.74, 3.57, and 1.07 for 1997,1999 and 2001. In 1999, a large fish kill of many thousands of adult shad and menhaden occurred in this reach of the river, associated with this low D.O. event. No low D.O. events were measured at the Acosta Bridge station between 1996 and 2001 that qualify for chronic impairment under the EPA guidance approach, with the greatest score being 0.73, recorded in1998.

Dinoflagellate Bloom Potential

The potential for nutrient and organic matter enrichment to stimulate the growth of marine dinoflagellate algal species represents one of the most significant detrimental effects attributable to estuarine eutrophication. Several toxic dinoflagellate species have been identified in regular plankton monitoring, including *Karolina breve* (red tide) and *Prorocentrum minimum*, and dinoflagellate infections have been postulated as a possible factor in ulcerative disease syndrome that plagued the LSJR during much of the early 1990's. A monitoring program conducted in 19__ with the objective of determining the presence of *Pfiesteria*–like species discovered a previously unidentified dinoflagellate, subsequently named *Cryptoperidineopsis brodii*, to reside in LSJR mesohaline reach sediments.

The tendency for dinoflagellate populations to increase in relative abundance under conditions of increasing potential diatom silica limitation leads to the possibility that high levels of nutrient enrichment, in excess of that balanced by bioavailable silica, may contribute disproportionately to dinoflagellate blooms. Dinoflagellate life cycles and survival strategies are extremely complex, however, and occurrence of high populations is poorly correlated with nutrient concentration or diatom biomass. For this reason, the limitation of dinoflagellate blooms exists as a qualitative target in LSJR TMDL development. In recent work investigating the relationship between nutrient enrichment effects on nuisance algal growth in the Indian River Lagoon, the occurrence of potentially toxic dinoflagellate blooms is identified as a significant water quality impairment (Phlips et al. (2003)). In this work, a level of 1,000,000 ?m^3/ml algal biovolume (roughly equivalent 6 μg/L chlorophyll *a*) is suggested to define a marine bloom condition.

Appendix D

Estimated Loads to the LSJR for 1995 – 1999

DRAFT

	Total N	Labile TON	Refractory TON	Total Inorganic N		Total P	Labile TNOP	Refractory TNOP	Total PO4		Total Organic C	Labile TOC	Refractory TOC
Table D1. Summary of Loads to the Lower St. Johns River, **1995**. All values in metric tons per year.													
Buffalo Bluff Total	10765.1	4336.2	5373.0	1056.0		511.2	207.3	96.9	207.0		138347.0	12976.2	125370.9
Natural Background	6659.7	1006.7	5432.5	220.5		290.8	97.9	97.3	95.6		131539.8	5727.6	125812.3
Dunns Creek Total	1372.5	290.7	919.0	162.8		108.2	33.6	35.4	39.1		23100.5	718.7	22381.9
Natural Background	915.7	112.0	779.9	23.7		61.3	15.0	31.4	14.9		19272.6	636.9	18635.7
<u>Upstream Total</u>	12137.7	4627.0	6291.9	1218.8		619.3	240.9	132.3	246.1		161447.5	13694.8	147752.7
<u>Fresh Tidal NP Total</u>	1068.4	371.7	505.6	191.1		211.2	54.9	22.7	133.6		23875.4	1709.8	22165.6
Natural Nonpoint	626.3	203.8	387.9	34.6		56.8	11.1	6.7	38.9		23213.7	1255.7	21957.9
Agriculture Contribution	384.1	126.1	124.7	133.4		136.9	35.4	13.4	88.1		217.9	173.7	44.2
Urban Contribution	53.2	39.3	-3.5	17.4		15.4	8.5	1.7	5.2		-507.8	171.4	-679.2
Other Nonpoint	4.7	2.5	-3.5	5.7		2.1	-0.1	0.9	1.3		951.7	109.0	842.7
<u>Point Source</u>	306.7	151.5	12.0	143.2		70.2	32.0	0.8	37.4		1417.6	814.6	603.0
<u>Oligohaline NP Total</u>	1141.3	517.8	447.3	176.3		186.8	79.2	16.7	90.9		25692.0	2584.6	23107.4
Natural Nonpoint	746.3	236.9	468.9	40.5		65.6	13.0	8.3	44.2		26852.0	1413.6	25438.4
Agriculture Contribution	26.2	10.7	2.0	13.5		10.9	2.1	0.5	8.3		1.5	46.5	-45.0
Urban Contribution	370.7	269.2	-10.1	111.6		110.0	64.0	7.8	38.2		-2062.9	1028.6	-3091.5
Other Nonpoint	-1.8	1.0	-13.5	10.7		0.5	0.0	0.2	0.3		901.5	96.0	805.5
<u>Point Source</u>	333.5	49.6	3.9	279.9		72.1	11.2	0.3	60.6		287.1	165.0	122.1
<u>Meso-Polyhaline NP Total</u>	440.2	223.2	120.6	96.4		92.0	44.0	6.6	41.4		6524.5	1002.8	5521.6
Natural Nonpoint	218.4	68.0	138.5	11.9		19.8	3.8	2.5	13.6		7509.0	385.0	7124.1
Agriculture Contribution	13.4	5.3	1.1	7.0		5.3	1.2	0.2	4.0		17.4	20.2	-2.8
Urban Contribution	209.9	151.9	-10.7	68.8		66.6	39.2	3.8	23.6		-1238.7	567.6	-1806.3
Other Nonpoint	-1.5	-2.1	-8.2	8.8		0.2	-0.2	0.2	0.2		236.7	30.1	206.6
<u>Point Source</u>	1147.4	238.9	18.9	889.6		294.4	46.9	1.2	246.2		1920.7	1103.7	817.0
Total Atmospheric Dep.	243.0					5.0							
LSJRB Summary													
Total Natural Nonpoint	1591.0	508.7	995.3	86.9		142.2	28.0	17.5	96.7		57574.7	3054.3	54520.4
Total Augmented Nonpoint	1059.0	603.9	78.2	376.8		347.9	150.2	28.6	169.1		-1482.8	2243.0	-3725.8
Total Point Source	1787.6	440.0	34.9	1312.7		436.6	90.2	2.3	344.2		3625.4	2083.3	1542.1
Grand Total	16818.3	6179.6	7400.4	2995.2		1551.0	509.2	180.6	856.1		221164.9	21075.5	200089.4

Notes: N= Nitrogen; P=Phosphorus; C=Carbon. NP=Nonpoint Sources. LSJRB Summary sums loads for only the lower St. Johns Basin downstream of Dunns Creek.

DRAFT

Table D2. Summary of Loads to the Lower St. Johns River, **1996.** All values in metric tons per year.

Source or Source Category	Total N	Labile TON	Refractory TON	Total Inorganic N	Total P	Labile TNOP	Refractory TNOP	Total PO4	Total Organic C	Labile TOC	Refractory TOC
Buffalo Bluff Total	8609.9	4828.1	3252.4	529.4	385.0	241.4	48.1	95.3	103597.6	17027.1	86570.5
Natural Background	4451.6	1100.3	3252.4	98.9	221.1	122.7	48.1	50.4	92828.8	6258.3	86570.5
Dunns Creek Total	898.0	172.5	595.7	129.8	42.5	11.8	13.7	17.1	16639.5	523.2	16116.3
Natural Background	716.0	85.8	595.7	34.5	34.1	9.6	13.7	10.9	16604.5	488.2	16116.3
Upstream Total	9507.9	5000.6	3848.1	659.2	427.5	253.2	61.7	112.5	120237.1	17550.3	102686.8
Fresh Tidal NP Total	578.6	187.5	289.3	101.8	93.6	25.7	11.5	56.4	13718.0	869.5	12848.4
Natural Nonpoint	365.6	105.5	243.7	16.5	32.0	6.0	4.5	21.5	13597.2	623.4	12973.8
Agriculture Contribution	177.0	56.0	49.7	71.3	51.8	15.0	5.6	31.2	-24.3	88.7	-113.0
Urban Contribution	30.8	25.7	-5.1	10.2	8.6	4.7	0.9	2.9	-334.6	118.2	-452.8
Other Nonpoint	5.2	0.3	1.0	3.9	1.3	0.0	0.6	0.7	479.7	39.2	440.4
Point Source	285.6	144.6	11.5	129.6	66.0	30.5	0.8	34.7	1340.4	770.2	570.1
Oligohaline NP Total	676.8	300.0	264.0	112.8	113.7	47.0	10.1	56.6	14393.1	1440.3	12952.7
Natural Nonpoint	427.3	124.3	281.9	21.0	38.3	7.1	5.2	26.1	15176.5	707.0	14469.4
Agriculture Contribution	18.0	7.2	1.8	9.0	6.6	1.2	0.2	5.1	8.0	29.6	-21.5
Urban Contribution	230.5	51.4	-13.5	77.0	68.0	38.6	4.5	24.9	-1383.4	645.9	-2029.3
Other Nonpoint	1.0	117.0	-6.2	5.8	0.8	0.1	0.2	0.4	592.0	57.8	534.2
Point Source	322.5	42.3	3.4	276.8	65.6	10.5	0.3	54.9	351.8	202.2	149.7
Meso-Polyhaline NP Total	422.7	210.3	119.2	93.2	87.2	39.6	6.3	41.3	6400.3	949.3	5451.0
Natural Nonpoint	211.3	62.5	137.7	11.0	19.6	3.5	2.5	13.5	7243.0	345.8	6897.3
Agriculture Contribution	17.8	6.6	1.8	9.4	7.5	1.6	0.3	5.6	42.9	25.0	17.9
Urban Contribution	193.3	141.7	-14.2	65.8	59.4	34.5	3.3	21.6	-1161.2	545.2	-1706.4
Other Nonpoint	0.4	-0.6	-6.2	7.1	0.8	-0.1	0.3	0.6	275.6	33.3	242.3
Point Source	1144.4	251.6	20.0	872.9	328.9	50.8	1.3	276.9	2199.7	1264.0	935.7
Total Atmospheric Dep.	243.0				5.0						
LSJRB Summary											
Total Natural Nonpoint	1004.2	292.3	663.4	48.5	89.8	16.6	12.1	61.2	36016.7	1676.3	34340.5
Total Augmented Nonpoint	673.9	405.5	9.1	259.3	204.6	95.7	15.8	93.1	-1505.4	1582.9	-3088.3
Total Point Source	1752.5	438.5	34.8	1279.3	460.5	91.7	2.3	366.5	3891.9	2236.4	1655.4
Grand Total	13181.5	6136.9	4555.3	2246.3	1187.5	457.1	91.9	633.2	####	23045.9	135594.5

Source or Source Category	Total N	Labile TON	Refractory TON	Total Inorganic N		Total P	Labile TNOP	Refractory TNOP	Total PO4		Total Organic C	Labile TOC	Refractory TOC
Buffalo Bluff Total	4849.3	3606.6	1061.3	181.4		173.2	148.6	12.9	11.6		55541.4	17236.2	38305.2
Natural Background	1880.2	792.5	1061.3	26.4		117.5	85.7	12.9	18.8		42814.0	4508.8	38305.2
Dunns Creek Total	933.4	318.0	564.3	51.2		59.9	27.1	15.6	17.2		17202.9	996.6	16206.3
Natural Background	711.2	133.1	564.3	13.8		35.8	15.2	15.6	4.9		16963.6	757.3	16206.3
Upstream Total	5782.7	3924.6	1625.5	232.6		233.1	175.7	28.6	28.8		72744.4	18232.8	54511.5
Fresh Tidal NP Total	992.8	341.2	430.4	221.2		158.4	54.4	20.6	83.4		20214.2	1522.6	18691.6
Natural Nonpoint	532.7	181.2	321.9	29.6		44.8	9.7	5.5	29.5		20183.5	1163.8	19019.7
Agriculture Contribution	405.3	122.0	109.6	173.7		97.5	35.5	12.1	49.9		-112.0	132.2	-244.1
Urban Contribution	49.1	39.2	-1.0	10.9		14.4	9.0	2.0	3.4		-439.7	167.9	-607.6
Other Nonpoint	5.7	-1.2	0.0	7.0		1.7	0.1	1.0	0.5		582.3	58.7	523.6
Point Source	299.6	86.6	73.1	139.7		69.1	24.0	7.0	38.1		4789.3	585.6	4203.6
Oligohaline NP Total	728.4	325.9	302.4	100.1		110.4	46.5	10.8	53.0		17709.8	1684.1	16025.7
Natural Nonpoint	501.7	163.3	310.9	27.4		42.8	8.9	5.4	28.4		18268.7	996.5	17272.1
Agriculture Contribution	16.4	6.8	1.3	8.4		6.9	1.3	0.3	5.3		-8.7	30.0	-38.7
Urban Contribution	211.9	156.1	-1.4	57.3		60.6	36.3	5.0	19.3		-1101.0	602.7	-1703.7
Other Nonpoint	-1.6	-0.3	-8.3	7.0		0.1	0.0	0.1	0.0		550.9	54.9	496.0
Point Source	341.3	45.9	9.8	285.6		73.6	11.5	0.7	61.5		321.6	143.8	177.8
Meso-Polyhaline NP Total	342.7	182.4	88.7	71.6		69.6	35.1	4.7	29.8		4914.8	822.6	4092.2
Natural Nonpoint	162.7	52.0	101.9	8.8		13.9	2.9	1.8	9.2		5644.2	300.8	5343.4
Agriculture Contribution	9.9	4.0	0.4	5.5		3.5	0.6	0.0	2.9		-8.1	14.7	-22.8
Urban Contribution	170.9	128.3	-8.5	51.1		52.0	31.6	2.7	17.7		-865.4	490.0	-1355.4
Other Nonpoint	-0.8	-1.9	-5.0	6.1		0.2	0.1	0.2	-0.1		144.1	17.0	127.1
Point Source	1187.7	251.1	33.7	902.9		334.6	71.4	3.1	260.1		2233.5	1354.5	879.0
Total Atmospheric Dep.	243.0					5.0							
LSJRB Summary													
Total Natural Nonpoint	1197.1	396.5	734.6	65.9		101.4	21.5	12.7	67.2		44096.4	2461.2	41635.2
Total Augmented Nonpoint	867.0	453.0	87.0	327.0		236.9	114.6	23.3	99.0		-1257.7	1568.1	-2825.7
Total Point Source	1828.6	383.6	116.6	1328.2		477.4	106.9	10.8	359.7		7344.4	2083.9	5260.5
Grand Total	9918.4	5157.8	2563.7	1953.6		1053.8	418.7	75.4	554.7		####	24346.0	98581.5

Table D3 Summary of Loads to the Lower St. Johns River, **1997**. All values in metric tons per year.

Table D4. Summary of Loads to the Lower St. Johns River, 1998. All values in metric tons per year.

	Total N	Labile TON	Refractory TON	Total Inorganic N		Total P	Labile TNOP	Refractory TNOP	Total PO4		Total Organic C	Labile TOC	Refractory TOC
Buffalo Bluff Total	8561.5	4942.4	3175.9	443.1		341.8	201.8	42.5	97.4		127323.1	21218.1	106105.0
Natural Background	4428.1	1189.7	3175.9	62.5		246.4	140.0	42.5	63.9		112873.9	6768.9	106105.0
Dunns Creek Total	971.2	217.6	681.9	71.7		51.3	15.8	15.9	19.7		21379.6	778.7	20600.9
Natural Background	813.6	108.2	681.9	23.5		39.4	11.1	15.9	12.4		21216.6	615.7	20600.9
Upstream Total	9532.7	5160.0	3857.8	514.9		393.1	217.6	58.4	117.1		148702.7	21996.9	126705.9
Fresh Tidal NP Total	1652.2	480.2	935.0	237.0		222.9	53.8	31.1	138.0		44053.4	2272.1	41781.4
Natural Nonpoint	1188.3	284.7	864.2	39.4		103.4	17.3	16.7	69.4		43976.7	1525.1	42451.6
Agriculture Contribution	350.3	111.7	93.9	144.7		92.2	27.3	11.9	53.0		-257.6	256.3	-513.9
Urban Contribution	110.4	92.5	-21.4	39.4		25.8	13.4	2.8	9.6		-817.6	443.8	-1261.4
Other Nonpoint	3.1	-8.7	-1.7	13.6		1.5	-4.2	-0.2	5.9		1151.9	47.0	1105.0
Point Source	274.2	82.4	57.1	134.5		62.1	21.9	5.1	35.0		4154.4	582.3	3572.2
Oligohaline NP Total	1236.9	492.7	565.8	178.4		171.8	63.8	18.4	89.6		28792.1	2331.6	26460.5
Natural Nonpoint	830.1	199.7	601.6	28.8		72.4	12.1	11.6	48.7		29623.8	1041.0	28582.8
Agriculture Contribution	35.9	17.9	9.5	8.5		8.7	5.9	2.4	0.5		-51.2	53.9	-105.1
Urban Contribution	374.4	282.0	-33.2	125.6		90.6	50.4	6.3	33.9		-1540.4	1200.2	-2740.6
Other Nonpoint	-3.5	-6.9	-12.1	15.4		0.1	-4.5	-1.9	6.5		759.8	36.5	723.3
Point Source	301.3	53.7	9.6	238.0		81.4	13.2	0.7	67.5		363.5	184.3	179.2
Meso-Polyhaline NP Total	867.0	436.2	254.1	176.7		152.0	68.5	11.4	72.1		13343.1	1966.9	11376.3
Natural Nonpoint	426.5	109.6	299.9	17.0		37.7	6.5	5.7	25.5		14672.1	570.9	14101.2
Agriculture Contribution	38.3	7.3	-1.5	32.5		11.8	-3.1	-1.1	16.1		29.8	49.8	-20.0
Urban Contribution	404.1	315.7	-40.2	128.6		101.5	59.8	4.8	36.9		-1741.7	1310.4	-3052.1
Other Nonpoint	-1.8	3.6	-4.1	-1.3		0.9	5.3	2.0	-6.3		382.9	35.8	347.1
Point Source	1267.0	279.4	38.3	949.3		341.5	70.7	3.3	267.6		2468.4	1500.7	967.7
Total Atmospheric Dep.	243.0					5.0							
LSJRB Summary													
Total Natural Nonpoint	2444.9	594.0	1765.7	85.2		213.5	35.8	34.0	143.6		88272.7	3137.0	85135.7
Total Augmented Nonpoint	1311.2	815.2	-10.8	506.8		333.2	150.3	26.8	156.1		-2084.0	3433.6	-5517.6
Total Point Source	1842.4	415.5	105.1	1321.8		485.0	105.8	9.1	370.1		6986.3	2267.2	4719.1
Grand Total	15374.2	6984.7	5717.8	2428.7		1429.8	509.5	128.4	786.9		241877.7	30834.6	211043.1

DRAFT

Source or Source Category	Total N	Labile TON	Refractory TON	Total Inorganic N	Total P	Labile TNOP	Refractory TNOP	Total PO4	Total Organic C	Labile TOC	Refractory TOC
Table D5. Summary of Loads to the Lower St. Johns River, 1999. All values in metric tons per year.											
Buffalo Bluff Total	5280.2	3876.3	1268.0	182.0	183.4	150.2	17.2	17.9	62627.4	17164.1	45463.3
Natural Background	2091.0	815.0	1250.3	25.7	121.3	83.3	16.9	21.1	50350.1	4637.0	45713.1
Dunns Creek Total	-166.6	-120.9	-45.0	-0.8	-8.9	-6.5	-1.9	-0.6	-1443.5	-401.8	-1041.7
Natural Background	-80.4	-35.3	-45.2	0.2	-3.9	-2.0	-1.9	0.0	-1263.6	-201.0	-1062.6
Upstream Total	5113.6	3755.4	1223.0	181.2	174.5	143.7	15.3	17.4	61183.8	16762.3	44421.6
Fresh Tidal NP Total	248.7	84.8	119.4	44.5	54.5	13.4	5.6	35.5	5143.3	352.4	4790.9
Natural Nonpoint	139.6	39.3	93.9	6.5	13.2	2.3	1.7	9.2	5064.1	221.0	4843.1
Agriculture Contribution	103.1	35.0	35.1	33.0	38.9	9.6	3.7	25.6	64.3	46.8	17.5
Urban Contribution	9.3	7.6	-1.4	3.2	2.6	1.5	0.2	0.9	-90.9	32.7	-123.5
Other Nonpoint	-3.3	3.0	-8.1	1.8	-0.2	0.0	0.0	-0.3	105.7	51.9	53.8
Point Source	275.3	144.0	11.4	119.8	64.5	30.3	0.8	33.4	1232.2	708.0	524.1
Oligohaline NP Total	236.9	103.3	93.4	40.2	40.8	16.0	3.6	21.2	5286.4	512.6	4773.7
Natural Nonpoint	162.4	45.3	109.1	7.9	15.6	2.6	2.0	10.9	5700.0	247.9	5452.1
Agriculture Contribution	5.9	2.3	0.5	3.1	2.6	0.5	0.1	2.0	9.5	10.2	-0.8
Urban Contribution	74.9	51.9	-3.5	26.5	23.4	12.8	1.7	9.0	-494.5	197.1	-691.6
Other Nonpoint	-6.3	3.8	-12.7	2.6	-0.8	0.1	-0.2	-0.7	71.4	57.3	14.0
Point Source	305.2	46.3	3.7	255.2	81.9	13.1	0.3	68.5	249.4	143.3	106.1
Meso-Polyhaline NP Total	156.5	76.9	44.0	35.7	33.1	14.9	2.4	15.9	2332.0	342.7	1989.3
Natural Nonpoint	79.9	21.9	54.1	3.9	7.6	1.3	1.0	5.4	2719.0	116.0	2603.0
Agriculture Contribution	6.9	2.6	0.8	3.6	2.8	0.6	0.1	2.0	16.6	9.6	7.0
Urban Contribution	71.4	51.6	-5.6	25.5	22.8	13.0	1.2	8.5	-451.4	195.3	-646.7
Other Nonpoint	-1.8	0.8	-5.3	2.7	0.0	0.0	0.0	0.0	47.9	21.8	26.1
Point Source	1121.5	206.0	16.3	899.2	330.3	50.0	1.2	279.1	1401.0	805.1	595.9
Total Atmospheric Dep.	243.0				5.0						
LSJRB Summary											
Total Natural Nonpoint	381.9	106.5	257.1	18.3	36.4	6.2	4.8	25.5	13483.1	584.9	12898.2
Total Augmented Nonpoint	260.2	158.5	-0.3	102.0	92.0	38.1	6.8	47.0	-721.5	622.8	-1344.2
Total Point Source	1702.0	396.4	31.4	1274.2	476.7	93.4	2.3	381.0	2882.5	1656.4	1226.1
Grand Total	7700.7	4416.8	1511.2	1575.7	784.6	281.4	29.2	470.9	76828.0	19626.4	57201.6

Appendix E

Description of State and Federal Stormwater Programs

State and Federal Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, Florida Statutes (F.S.), was established as a technology-based program that relies upon the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, Florida Administrative Code (F.A.C.).

The rule requires Water Management Districts (WMDs) to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a SWIM plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG has been developed for Newnans Lake at the time this study was conducted.

In 1987, the U.S. Congress established section 402(p) as part of the Federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES to designate certain stormwater discharges as "point sources" of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific Standard Industrial Classification (SIC) codes, construction sites disturbing five or more acres of land, and master drainage systems of local governments with a population above 100,000 [which are better known as "municipal separate storm sewer systems" (MS4s)]. However, because the master drainage systems of most local governments in Florida are interconnected, EPA has implemented Phase 1 of the MS4 permitting program on a county-wide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the DOT (Department of Transportation) throughout the 15 counties meeting the population criteria.

An important difference between the federal and the state stormwater permitting programs is that the federal program covers both new and existing discharges while the state program focuses on new discharges. Additionally, Phase 2 of the NPDES stormwater permitting program will expand the need for these permits to construction sites between one and five acres, and to local governments with as few as 10,000 people. These revised rules require that these additional activities obtain permits by 2003. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that can not be easily collected and treated by a central treatment facility similar to other point sources of pollution, such as domestic and industrial wastewater discharges. The DEP recently accepted delegation from EPA for the stormwater part of the NPDES program. It should be noted that most MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.

Appendix F

Example DO Calibration Figures for the Water Quality Model
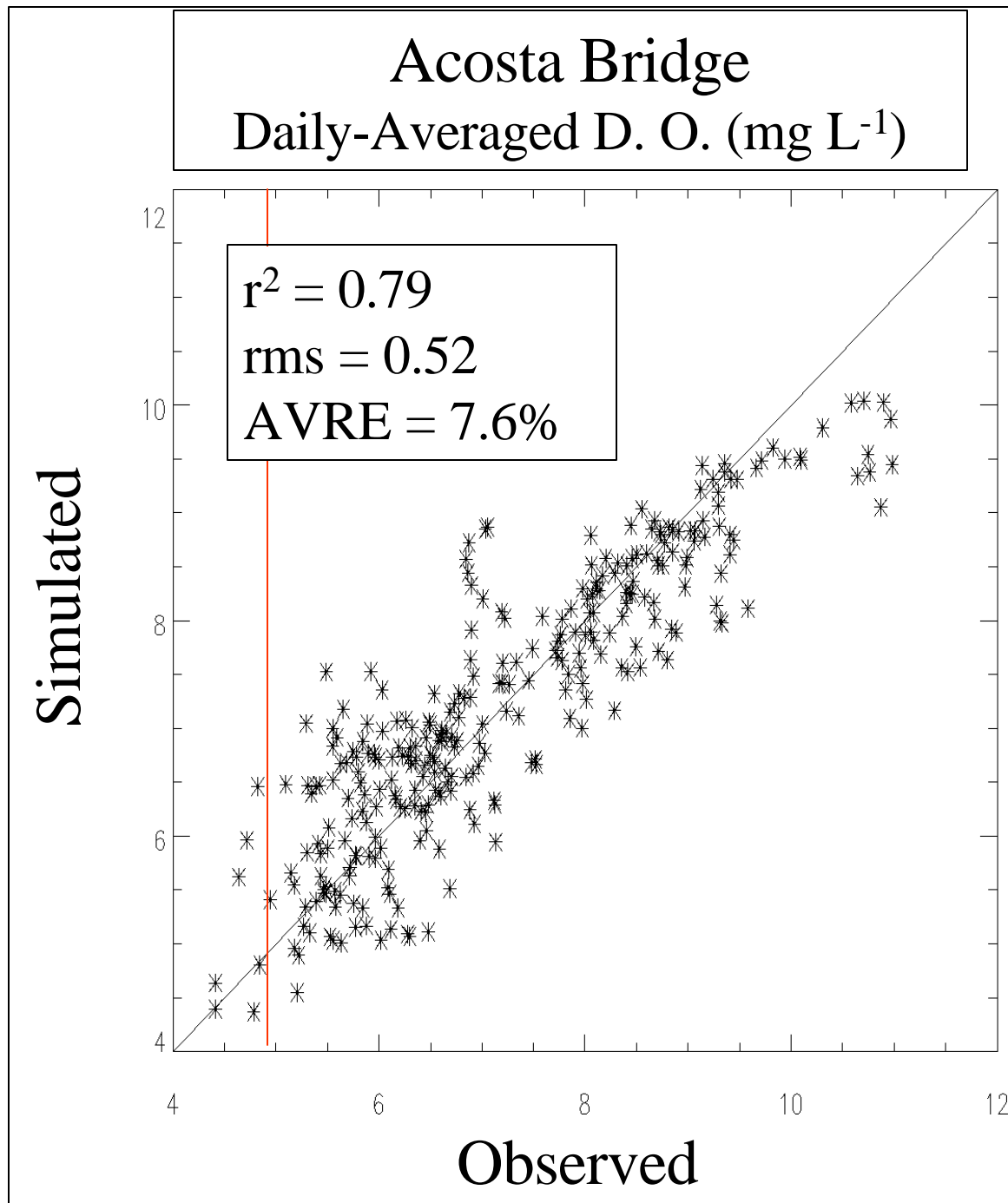
Figure E1. Accuracy of Model DO Predictions for Acosta Bridge
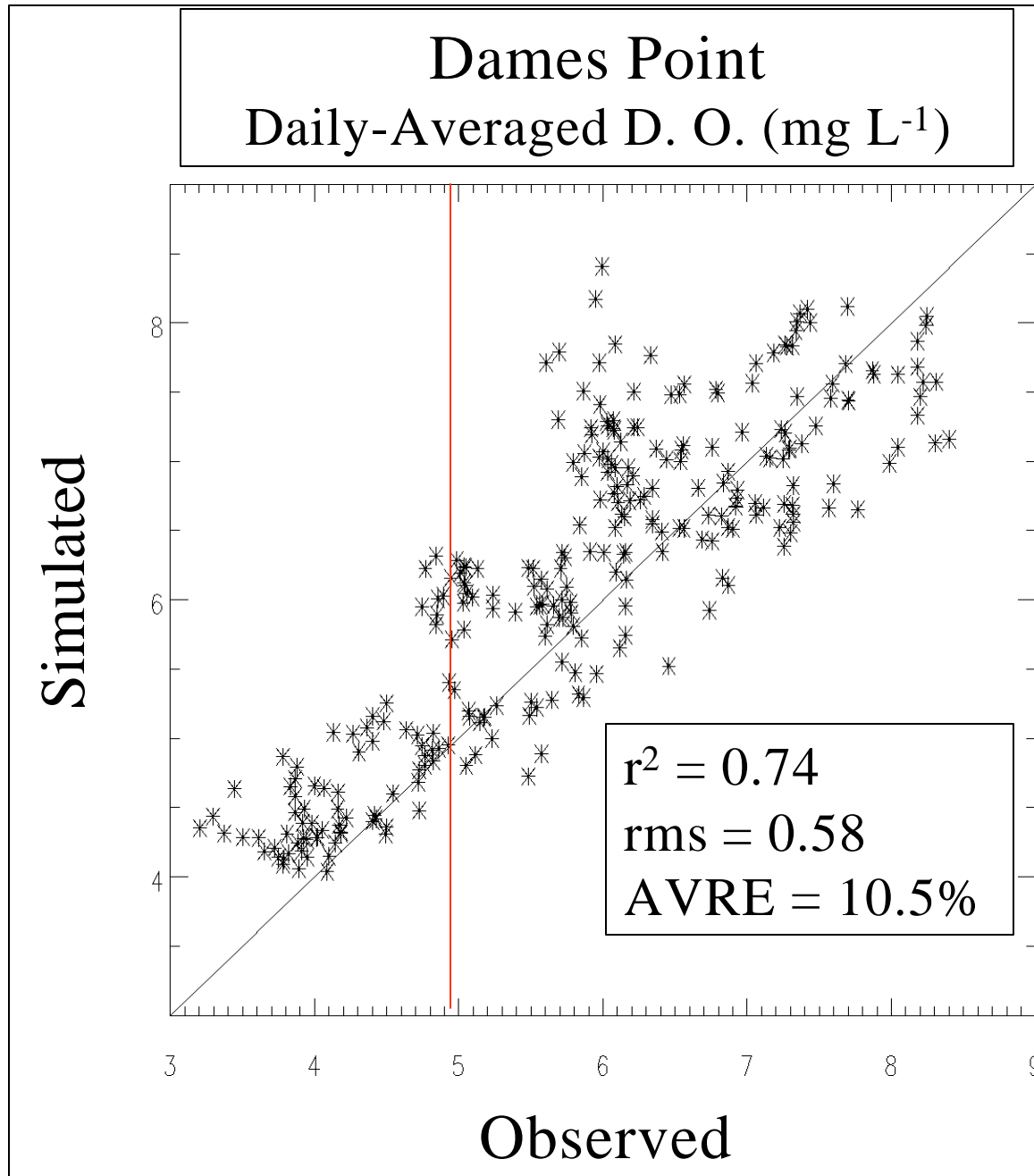
Figure E2. Accuracy of Model DO Predictions for Dames Point

Appendix G

Example Chlorophyll *a* Calibration Figures for the Water Quality Model

Figure F1. Comparisons of Model Predictions Versus Measured Values for Chlorophyll *a* at Racy Point
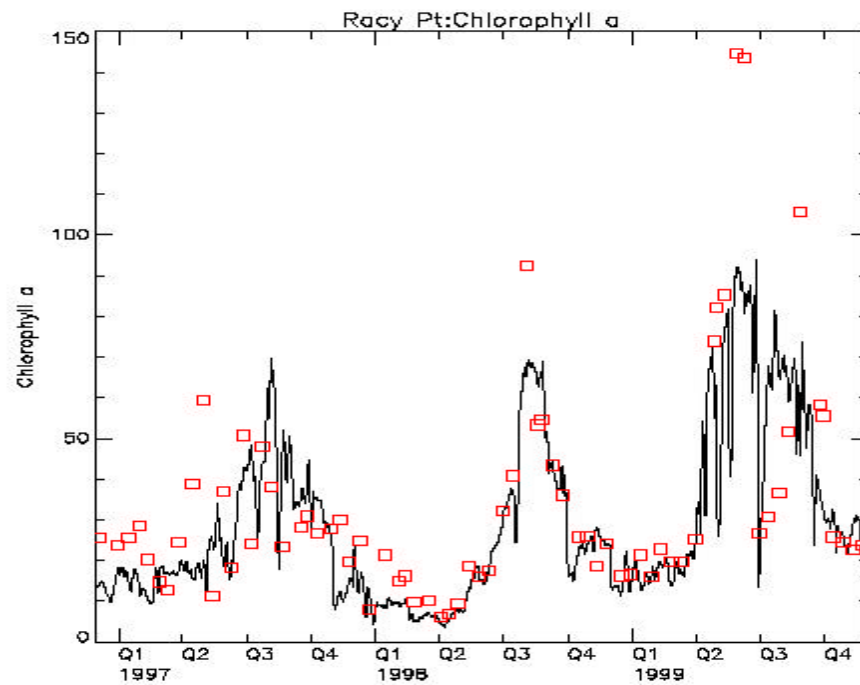
Figure F2. Comparisons of Model Predictions Versus Measured Values for Chlorophyll *a* at Watson Island
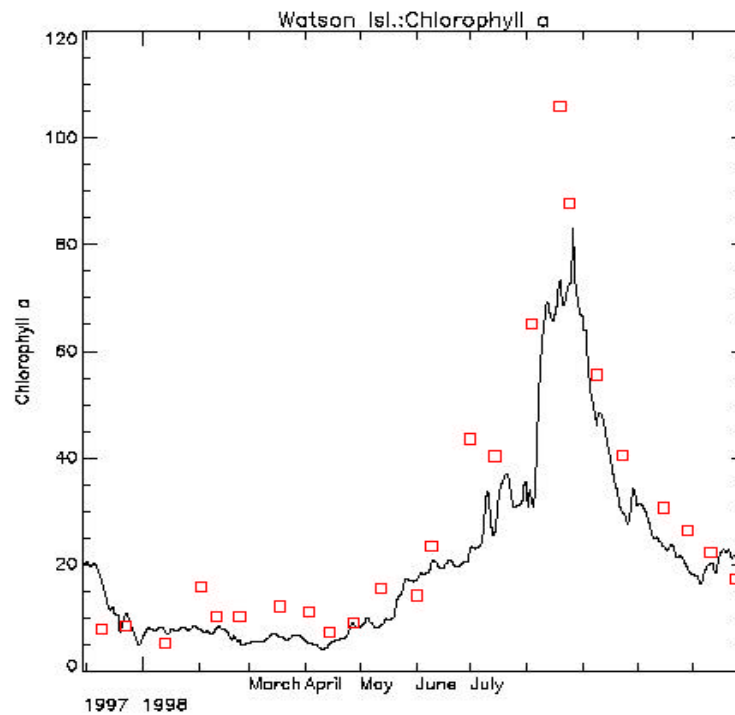
Figure F3. **Accuracy of Model Predictions of Average Annual Chlorophyll *a* for Freshwater Section**

Average Annual Chlorophyll Freshwater Section

r² = 0.81
rms error = 3.9
slope = 0.67
intercept = 6.2

Simulated Average Chlorophyll

Observed Average Chlorophyll
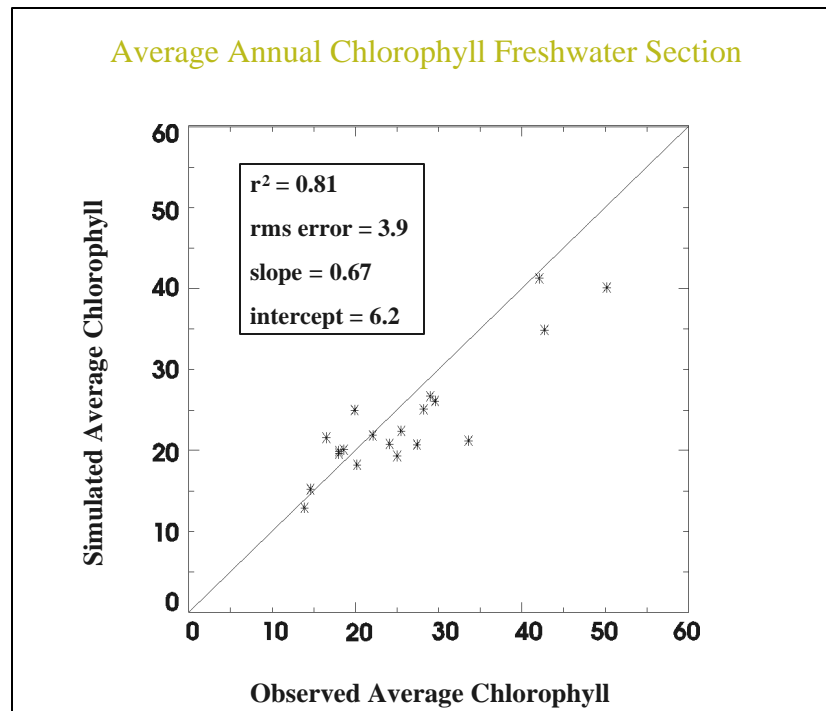
Figure F4. **Accuracy of Model Predictions for Chlorophyll *a* Percent Exceedances for the Freshwater Section**

Percent Exceedence of 40 ?gL⁻¹ Chlorophyll Freshwater Section

r² = 0.75
rms error = 5.1
slope = 0.76
intercept = 3.5

Simulated % Exceedence of 40 ?gL⁻¹ Chlorophyll

Observed % Exceedence of 40 ?gL⁻¹ Chlorophyll
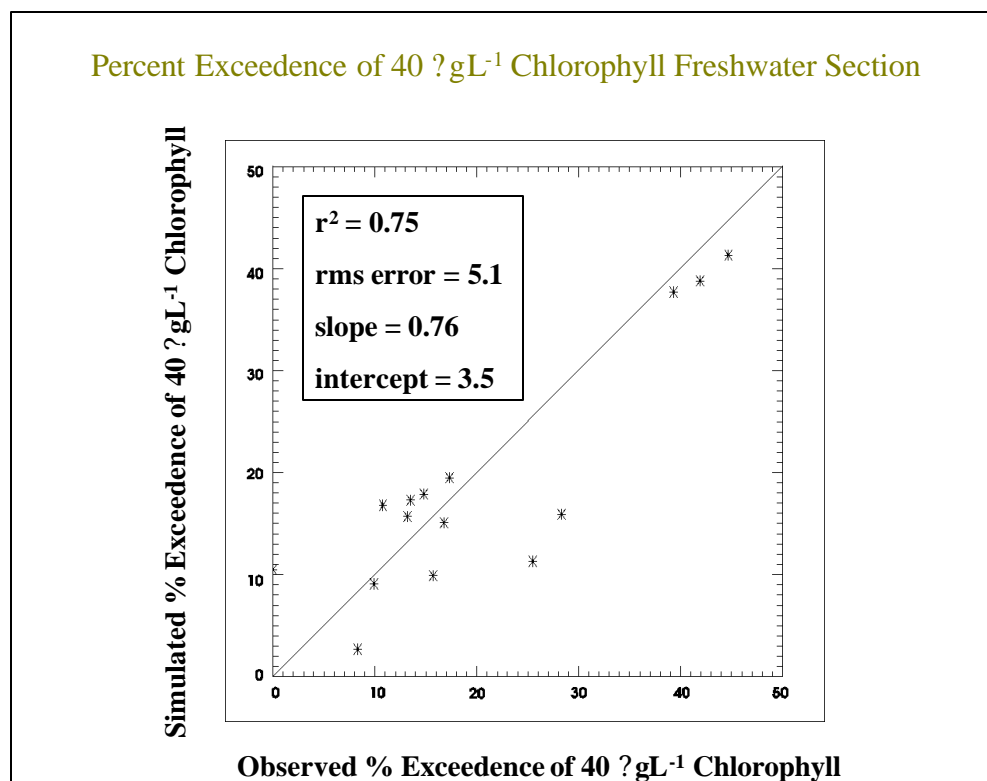
Appendix H
Allocation Spreadsheets for the Freshwater and Estuarine Portions of the LSJR

Fresh Water Portion of River   Nitrogen   kg/yr   Average of 95,97,98,99

Source Category or Name of Facility	Current Load	Starting Load for Point Sources	Level 2 Reduction	Committed or Level 3 Reduction	Total Reduction	Adjusted Load	Net Reduction from Current
Point Sources							
GEORGIA-PACIFIC	258155	258155	0	92245	92245	165909	35.73%
PALATKA WWTF	56077	60889	0	20093	20093	40795	33.00%
GCS Harbor	5857	9457	0	9457	9457	0	100.00%
GCS South	5077	5143	0	5143	5143	0	100.00%
HASTINGS WWTF	647	647	0	4	4	643	0.63%
PS TOTAL	**325812**	**334290**	**0**	**126943**	**126943**	207347	37.97%
WMD PS TOTAL	287500	287500			126943	160557	44.15%
Natural Background							
Natural Buff Bluff	4018600	4018600				4018600	0.00%
Non-point							
Natural Dunns Creek	580700	580700				580700	0.00%
Natural Other Non-point	621700	621700				621700	0.00%
Total Natural Background	5221000	5221000				5221000	0.00%
Anthro Loads							
Augmented Buff Bluff	3937700	3937700	1299441	16568	1316009	2621691	33.42%
Point Source total	287500	334290		126943	126943	207347	37.97%
Augmented Nonpoint							
Aug Dunns Creek	190600	190600	38120	958	39078	151522	20.50%
Agriculture	310700	310700	111852	1249	113101	197599	36.40%
Urban	55500	55500	8186	297	8483	47017	15.29%
Other	2600	2600	0	16	16	2584	0.63%
Augmented NPS Total	559400	559400	158158	2520	160678	398722	28.72%
Total Anthro	4784600	4831390	1457599	146031	1603630	3227760	33.19%
Atm Deposition	**121500**	**121500**				**121500**	**0.00%**
Total Load	**10165412**	**10173890**	**1457599**	**272974**	**1603630**	**8570260**	
WMD Total	10005600	10005600					

			Additional				
Target using start point			reduction	0.62800476	1603630	8570260	33.19%
Target using WMD load					1435340	8570260	30.00%

Difference between Point Source starting point and WMD used start load	168290	So a 30% reduction in anthropogenic load from the WMD's used current load starting point translates to a 33% reduction from point sources approved starting point based on Executive Commmittee approved methodology

	Point source				
WLA =	Total				
WLA =	207347			=	207347
	Natural	Anthro	Atm		
LA =	Nonpoint +	Nonpoint +	Depostion		
LA =	5221000	398722	121500	=	8362913
TMDL =	WLA +	LA+	MOS	=	
TMDL =	207347	8362913	implicit	=	8570260

DRAFT

Fresh Water Portion of River   Phosphorous   Average of 95,97,98,99

Source Category or Name of Facility	Current Load	Starting Load for Point Sources	Level 2 Reduction	Committed or Level 3 Reduction	Total Reduction	Adjusted Load	Net Reduction from Current
Point Sources							
GEORGIA-PACIFIC	63875	63875	0	30693	30693	33182	48.05%
PALATKA WWTF	9125	9955	0	3285	3285	6670	33.00%
GCS Harbor	1842	2986	0	1842	1842	1145	61.67%
GCS South	863	879	0	863	863	17	98.11%
HASTINGS WWTF	50	88	0	4	4	84	4.42%
PS TOTAL	**75754**	**77783**	**0**	**36686**	**36686**	41097	**45.75%**
WMD PS TOTAL	66200	66200			36686	29514	55.42%
Natural Background							
Natural Buff Bluff	204200	204200				204200	0.00%
Non-point							
Natural Dunns Creek	28900	28900				28900	0.00%
Natural Other Non-point	54500	54500				54500	0.00%
Total Natural Background	287600	287600				287600	0.00%
Anthro Loads							
Augmented Buff Bluff	106700	106700	35211	5585	40796	65904	38.23%
Point Source total	66200	66200		36686	36686	29514	55.42%
Augmented Nonpoint		0					
Aug Dunns Creek	23700	23700	4740	1481	6221	17479	26.25%
Agriculture	91400	91400	10054	6355	16409	74991	17.95%
Urban	14600	14600	4234	810	5044	9556	34.55%
Other	1300	1300	0	102	102	1198	7.81%
Augmented NPS Total	131000	131000	19028	8748	27776	103224	21.20%
Total Anthro	303900	315483	54239	51019	105258	198642	34.64%
Atm Deposition	**2500**	**2500**	**0**			**2500**	**0.00%**
Total Load	**603554**	**605583**	**54239**	**87706**	**105258**	**500325**	
WMD Total	591500	591500					
Target using start point			reduction beyond BMPS	7.812434593	105258	500325	33.36%
Target using WMD load					91175	500325	30.00%

Difference between Point Source starting point and WMD used start load	14083	So a 30% reduction in anthropogenic load from the WMD's used current load starting point translates to a 33% reduction from point sources approved starting point based on Executive Commmittee approved methodology	

	Point source				
WLA =	Total				
WLA =	41097			=	41097
	Natural	Anthro	Atm		
LA =	Nonpoint +	Nonpoint +	Depostion		
LA =	287600	103224	2500	=	459228
TMDL =	WLA +	LA+	MOS	=	
TMDL =	41097	459228	implicit	=	500325

Source Category or Name of Facility	Current Load	Starting Load for Point Sources	Level 2 Reduction	Level 3 Reduction	Total Reduction	Adjusted Load	Net Reduction from Start Point	Flow Starting Point	N Starting Pt
Point Sources - Marine									
Smurfit-Stone Container	83286	83286		5652	5652	77634	6.79%	8.85	6.8
Smurfit - Jax	70511	73166		20436	20436	52730	27.93%	6	8.8
USN - Mayport WWTF	4347	4480		0	0	4480	0.00%	1.03	3.2
NAS - Jax WWTF	12775	13273		3380	3380	9893	25.46%	1.13	8.5
Jax Beach WWTF	38657	40150		12228	12228	27922	30.45%	3.2	9.1
Neptune Beach WWTF	11448	11448		3202	3202	8246	27.97%	0.94	8.8
Westminster Woods	315	315		0	0	315	0.00%	0.05	4.6
Atl Beach - Buccanneer	18582	21070		11041	11041	10029	52.40%	1.13	13.4
JEA - Mandarin	34343	51764		0	0	51764	0.00%	7	5.34
JEA - Monterey	47284	56575		24715	24715	31860	43.69%	3.6	11.3
JEA - Holly Oaks	11448	0		0	0	0	0.00%	0	8.3
JEA - San Jose	28868	31191		11399	11399	19791	36.55%	2.25	10
JEA - Jax Heights	16591	22564		8432	8432	14132	37.37%	1.62	10.1
Orange Park WWTF	22066	24886		13278	13278	11608	53.36%	1.34	13.5
JEA - San Pablo	4148	6636		168	168	6469	2.53%	0.75	6.5
CCUA - Miller St	21236	31357		0	0	31357	0.00%	4.99	4.5
JEA - Ortega Hills	3252	0		0	0	0	0.00%	0	16.8
JEA - Buckman	480307	492086		195897	195897	296190	39.81%	34.02	10.5
JEA - Arlington	214686	355543		198293	198293	157250	55.77%	18	14.3
JEA - District II	135714	168564		122252	122252	46312	72.53%	5.4	22.7
JEA - SW	85111	145170		57583	57583	87588	39.67%	10	10.5
JEA - Royal Lakes	25218	32020		6047	6047	25974	18.88%	2.99	7.8
FWSC - Beacon Hiils	12277	16425		7618	7618	8807	46.38%	0.99	11.9
FWSC - Woodmere	5641	10120		4659	4659	5461	46.04%	0.64	11.6
CCUA - Fleming Oaks	1244	1676		0	0	1676	0.00%	0.4	3
Atl Beach - Main	26877	28205		12606	12606	15598	44.70%	1.8	11.4
An Busch - Mn St	13323	13936		0	0	13936	0.00%	2.6	3.9
JEA - Jul Crk	6968	7964		3729	3729	4235	46.82%	0.476	12
CCUA - Flem Isl	979	28536		10449	10449	18088	36.62%	2.0623501	10
UWF - St. Johns North	2074	0		0	0	0	0.00%	0	6.5
Brierwood SD	0	0		0	0	0	0.00%	0	
JEA Total	1093938	1370077		628513	628513	741564	45.87%		
CCUA - Total	23460	61569		10449	10449	51120	16.97%		
PS TOTAL	1439577	1772407	0	733063	733063	1039344	41.36%		
JEA Total	1093938	1370077		566661	306280	803417	41.36%	26.6%	
CCUA - Total	23460	61569		25465	25465	36104	41.36%		
PS TOTAL	**1439577**	**1772407**	**0**	**733063**	**733063**	**1039344**	**41.36%**	**27.80%**	
WMD PS TOTAL	1426700	1426700			733063	693637	51.38%	27.15%	
Natural Background	242300	242300				242300	0.00%		
Anthro Loads - Marine									
Point Source total	1426700	1772407		733063	733063	1039344	**41.36%**		
Augmented Nonpoint									
Agriculture	12800	12800	4608	3388	7996	4804	62.47%		
Urban	146300	146300	21579	51584	73163	73137	50.01%		
Other	-8100	-8100		0	0	-8100	0.00%		
Augmented NPS Total	151000	151000	26187	54972	81160	69840	53.75%		
Total Anthro	1577700	1923407	26187	788036	814223	1109184	42.33%		
Atm Dep - Marine	121500	121500				121500	0.00%		
Upstream from Fresh	**4358643**	**4358643**				**4358643**			
Augmented upstream	2347012					2347012			
Natural Upstream	2011631					2011631			
Total Load w/o fresh	**1954377**	**2287207**	**26187**	**788036**	**814223**	**1472984**			
Total Load w/ fresh	**6313019**	**6645849**							
WMD Total w/o fresh	1820000	1820000							

				Additional reduction					
Target using start point				41.3597583	814223	1472984	42.33%		
Target using WMD load						347016	1472984	22.00%	

Difference between Point Source starting point and WMD used start load	467207	So a 22% reduction in anthropogenic load from the WMD's used current load starting point translates to a 41% reduction from point sources approved starting point based on Executive Commmittee approved methodology

	Point source		Urban		
WLA =	Total	+	Stormwater		
WLA =	1039344	+	73137	=	1112480
	Natural	Anthro	Urban	Atm	
LA =	Nonpoint +	Nonpoint -	Stormwater +	Depostion =	
LA =	242300	69840	-73137	121500	360504
TMDL =	WLA +	LA+	MOS	=	
TMDL =	1112480	360504	implicit	=	1472984